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CHANGES IN THE NUMBERING OF REVIEW CHARTS

Beginning with the January, 1928, issue the series of REVIEW charts will be numbered as follows:

Chart I. Departure (°F.) of the mean temperature from normal.
Chart II. Tracks of centers of anticyclones.
Chart III. Tracks of centers of cyclones.
Chart IV. Percentage of clear sky between sunrise and sunset.
Chart V. Total precipitation (inches)
Chart VI. Isobars at sea level, isotherms at surface, and prevailing winds.
Chart VII. Total snowfall (inches), cold season only.

The charts of the North Atlantic Ocean will continue as at present, starting with No. VIII.

CORRECTIONS

REVIEW, January, 1928:

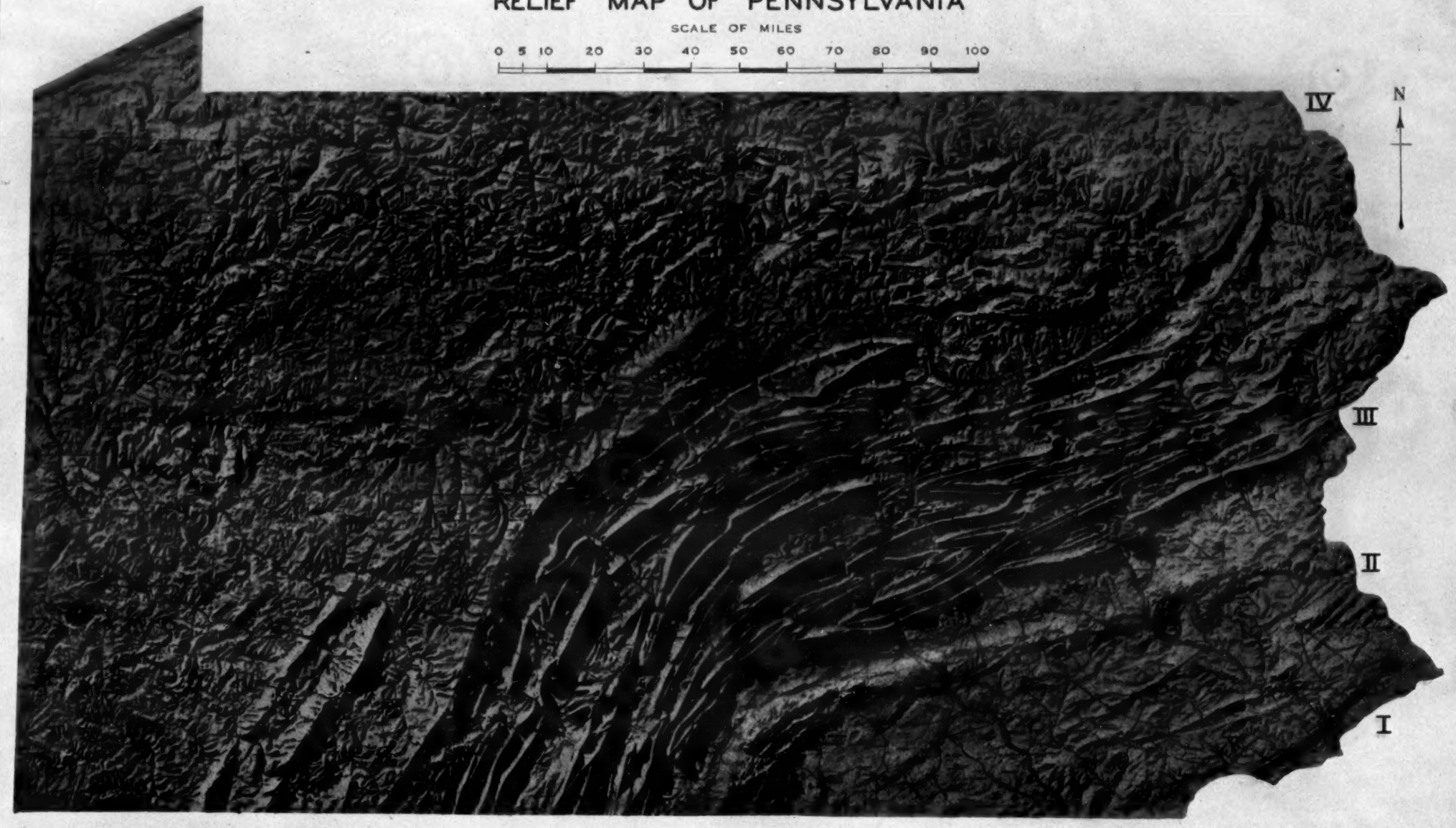
Page 9, the two charts (figs. 2 and 3) are upside down.

M. W. R., February, 1928

RELIEF MAP OF PENNSYLVANIA

SCALE OF MILES

0 5 10 20 30 40 50 60 70 80 90 100



I - COASTAL PLAIN
II - PIEDMONT PLATEAU
III - APPALACHIAN HIGHLANDS
IV - APPALACHIAN PLATEAU

(To face p. 35)

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MONTHLY WEATHER REVIEW

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FEBRUARY, 1928

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THE CLIMATE OF SOUTHEASTERN PENNSYLVANIA [1]

By PROF. HENRY F. JAMES

[University of Pennsylvania, Philadelphia, Pa.]

The greatest influence that nature exerts over man's temporal well-being is through climate. Man is a puppet, due to practically uncontrollable atmospheric forces. Helpless and almost powerless, he watches with fear and misgivings or with joy and ecstasy the march of the seasons with their ever changing parade of storms, sunshine, rain, wind, sleet, hail, and snow. His religion, in fact almost his very life, is molded and fashioned by temperature, moisture, sunshine, wind, and storm. He is a gambler by necessity because of atmospheric conditions that are all pervading and all powerful.

Climatic influences being important in the economic development of all lands and peoples, an analysis of the climate of southeastern Pennsylvania is essential to a clear understanding of its conditions, possibilities, and prospects. Southeastern Pennsylvania in this paper includes all land lying between South Mountain and Philadelphia in the province called by the physiographers, the Pennsylvania Piedmont. (See frontispiece.)

Temperature.—In temperature, one of the main meteorological factors, this region occupies a favorable position on the climatic chart, for its average annual temperatures approach closely the average for the entire world (59° F.). Due to its intermediate position, its temperatures are at times equable when the oceanic influence is in the ascendancy and decidedly variable when dominated by continental conditions. Its temperatures can also be said to partake slightly of the nature of both at times. The oceanic influence is less noticeable than on the Pacific coast of the United States in the same latitude because of its position on the windward side of the Atlantic Ocean. The reverse is true of the continental influence.

The region also extends into the zone of activity of the barometric depressions or storms that are frequent western visitors to northeastern United States by way of the Great Lakes and the St. Lawrence Valley. The visits of these cyclones and anticyclones are most numerous during the cold months with the result that every type of weather almost may be experienced during the winter period. February, 1899, saw minimum temperatures as follows: February 9, 1° F. below zero; 10th, 6° F. below; and the 11th, 6° F. below. This, however, was the only time in 40 years when the temperature reached or passed below the zero mark on two or more successive dates. Cold waves, however, are decidedly modified when they reach the Atlantic coast. The records of the Weather Bureau state that on the average only 3 out of every 12 cold waves that enter the United States in the extreme Northwest retain sufficient severity to be so classified on reaching southeastern Pennsylvania. In contrast with February, 1899, we have January, 1790, with a mean temperature of 12° F. above the normal. Of this month Charles Peirce says,[2] "The midday temperatures were frequently 70° in the shade, and boys were seen swimming in the Delaware."

Relative inactive atmospheric elements prevail during the summer months due to the less frequent and less intense development of the cyclones and anticyclones. The temperature conditions of land and water during this period are more uniform, a condition that produces a sluggish and inactive atmosphere. The general absence of clouds allow for the excessive heating of the earth and adjacent atmosphere at times. Such conditions are indicated in the records of the Philadelphia Weather Bureau, which show that from June 25 to July 6, 1901, there was a period of intense heat. The maximum temperature was 90° F. or above on 12 successive days. On July 2, the maximum temperature reached 103° F. June, 1925, also produced an intense heat period. During this time 7 successive days with a maximum temperature above 90° F. occurred. One hundred years earlier, the Democratic Press of Philadelphia under the heading, "Warm Weather," reported that on Thursday, June 9, 1825, a thermometer on the south side of Chestnut Street, between Second and Third Streets, fronting the north was as high as 96° F. The same thermometer at the same hour and exposure reached 97° F. on Friday and 96° F. on Saturday. These hot periods are usually broken by cyclonic and anticyclonic movements for a week or so that finally culminate in a period of very general thunderstorms and a shift of the wind to a northerly quarter. Any pressure formation that will bring about a shift of the wind to a northerly quarter, such, for example, as the northward movement off the coast of a West Indian hurricane is also effective in producing a lowering of the summer temperature. Cases of this sort are, however, rather infrequent. The thunderstorms are storms of only short duration, but are at times of great intensity.

The summer temperatures are not always hot in this region. The year 1816 is known as "The year without a summer." From the diary of Charles Peirce,[2] we notice the following statements. "May—Ice froze from a quarter to a half inch in thickness. Corn was planted two or three times and froze out. A melancholy hue seemed to seal the fate of all vegetable life. June—the coldest

[1] All statistics, unless otherwise indicated, obtained from the U. S. Weather Bureau records at Philadelphia.

[2] Peirce, Charles, Meteorological Account of the Weather in Philadelphia from Jan. 1, 1790 to Jan. 1, 1847.

June on record. Killing frosts occurred on several mornings and nearly all vegetables were killed. July—a month of heavy frosts and ice. On the morning of the 5th ice formed as thick as window glass. August—ice formed a half inch in thickness and everything green was destroyed."[1]

The temperature of this region is not ordinarily subject to the extremes that visit the interior United States. Temperatures of 110° F. have been recorded in the Dakotas. In Montana the midwinter temperatures often reach 25° or 30° F. below zero. The temperature, too, is moderate as compared with other parts of the State. Lawrenceville in central Pennsylvania reports a minimum temperature of 39° F. below zero. Claysville, western Pennsylvania, has experienced a maximum temperature of 108° F. Temperatures of 100° F. or higher are rarely recorded in this region, but the high humidity, sometimes makes the temperature conditions oppressive. During the hottest periods of summer the wind movement is generally light and affords but little relief. These periods, however, are generally broken up within a week or 10 days by fresh northeast winds. The winters are mild, there being an average of less than 100 days with a minimum temperature below the freezing point while zero temperatures are seldom reached more than once or twice during the winter season. Between 1874 and 1924 inclusive only 23 days with a temperature below zero were recorded in Philadelphia. Temperature conditions over an extended period are indicated in Tables 1 and 2.

TABLE 1.—*Average number of days with temperature 90° F. or above*

	January	February	March	April	May	June	July	August	September	October	November	December	Total	Years of record
Gettysburg	0	0	0	0	2	5	10	6	2	0	0	0	25	20
Reading	0	0	0	0	1	4	8	4	2	0	0	0	19	21
Philadelphia	0	0	0	0	0	3	6	3	1	0	0	0	13	37
State College	0	0	0	0	0	1	2	2	1	0	0	0	6	25
Pittsburgh	0	0	0	0	1	3	7	4	2	0	0	0	17	46
Erie	0	0	0	0	0	0	1	1	0	0	0	0	2	48

TABLE 2.—*Average number of days with temperature 32° F. or below*

	January	February	March	April	May	June	July	August	September	October	November	December	Total	Years of record
Gettysburg	27	25	20	7	0	0	0	0	0	4	16	26	125	20
State College	28	22	22	9	1	0	0	0	0	4	16	27	129	25
Erie	27	25	23	8	0	0	0	0	0	1	11	23	118	48
Pittsburgh	24	22	15	5	0	0	0	0	0	1	10	21	98	46
Philadelphia	22	20	13	2	0	0	0	0	0	0	6	18	81	40
Reading	26	25	18	5	0	0	0	0	0	2	12	25	113	21
West Chester	25	24	16	5	0	0	0	0	0	1	11	24	106	20

Neither areal extent nor relief is sufficiently great to produce outstanding contrasts within the area. Slight variations are caused by (1) differences in elevation; (2) location in relation to the ocean and latitude; and (3) slight differences in the exposure of the instruments.

[1] Against this pessimistic view see the following excerpt from the Boston Recorder of Aug. 7, 1816: In relation to the season, accounts from all parts of the country present an agreeable reversal of the gloomy reports which were made a few weeks ago. Fruits of every description will be abundant. All kinds of grain except corn are more promising than in ordinary seasons.

Tables Nos. 1, 2, 3, and 4 indicate the outstanding differences of temperature between representative places within the area and selected stations elsewhere in Pennsylvania.

TABLE 3.—*Temperature, elevation, and distance from nearest water body*

Station	Average mean winter, Dec.–Feb.	Average mean summer, June–Aug.	Average mean spring, Mar.–May	Average mean fall, Sept.–Nov.	Annual mean temperature	Mean maximum annual	Mean minimum annual	Elevation above mean sea level	Distance, Miles
Philadelphia (Coastal Plain).	33.86	74.1	51.6	56.9	54.1	62.1	46.4	157	50
	Jan.	July	Mar.	Sept.		July	Jan.		
	32.7	76.5	40.6	68.1		84.5	26		
Coatesville (Chester Valley).	31.1	71.4	50.6	54.4	51.9	63.4	42	380	85
	Feb.	July	Mar.	Sept.		July	Feb.		
	29.9	74.7	39.4	66.1		86.4	20.2		
West Chester-Trenton.	31.3	71.9	49.6	54.2	51.8	61.3	43.6	450	75
	Jan.	July	Mar.	Sept.		July	Feb.		
	30.2	74.3	38.3	65.3		84.7	21.4		
Lancaster (Limestone Plain).	30.9	72.1	49.9	53.6	51.6	63.8	40.0	255	110
	Jan.	July	Mar.	Sept.		July	Feb.		
	29.6	73.4	38.0	64.5		86.4	19.4		
York (Limestone Valley).	30.5	72.3	50.6	53.9	51.8	63.0	41.3	400	125
	Jan.	July	Mar.	Sept.		July	Jan.		
	29.3	74.4	39.4	65.6		86.6	20.4		
Quakertown (Triassic Lowlands).	28.8	69.3	48.1	52.3	49.6	61.5	39.9	496	65
	Jan.	July	Mar.	Sept.		July	Feb.		
	27	72.5	36.3	63.6		86.0	18.5		
Gettysburg (Triassic Lowlands).	30.3	71.8	50.3	52.8	51.3	63.1	41.4	600	135
	Jan.	July	Mar.	Sept.		July	Feb.		
	29	74.0	39.2	65.0		86.9	19.7		
Erie	28.2	68.9	45.0	52.6	48.7	55.9	41.6	714	0
	Feb.	July	Mar.	Sept.		July	Feb.		
	25.8	71.2	33.6	63.2		78.3	18.4		

Frost.—Of all portions of Pennsylvania this region is the most highly favored as regards the length of the frost-free season. Philadelphia, with a minimum growing season of 157 days and an average season of 207 days, is the most favored. The South Mountain farming districts are handicapped by a much shorter period free from frost. In the most important farming sections frosts are infrequent between May 1 and October 1. The latest date (Government records) for frost was May 29 (Quakertown station). Farmers in most parts of the area can depend on an average growing season of approximately 180 days, varying from 160 days at Quakertown to 207 days in the vicinity of Philadelphia. (See Table 4.)

TABLE 4.—*Frost dates*

	Average date of last killing	Latest date	Average date of first killing	Earliest date	Average growing season	Minimum growing season	Elevation, feet	Years of record
Gettysburg	Apr. 21	May 14	Oct. 19	Sept. 22	181	131	600	18
Lancaster	Apr. 27	May 27	Oct. 6	Sept. 11	162	107	255	13
State College	Apr. 29	May 29	...do...	...do...	160	105	1,217	36
York	Apr. 23	May 17	Oct. 8	...do...	168	149	400	16
Erie	Apr. 20	...do...	Oct. 2	Sept. 9	196	145	714	37
Pittsburgh	Apr. 21	May 20	Oct. 22	Sept. 25	184	119	842	48
Coatesville	Apr. 20	May 12	Oct. 17	Sept. 22	180	133	380	27
Philadelphia	Apr. 7	May 29	Oct. 31	Sept. 3	207	157	156	48
Quakertown	Apr. 30	...do...	Oct. 7	Sept. 15	160	109	496	24
Reading	Apr. 15	May 5	Oct. 15	Sept. 1	193	149	325	25
Kennett Square	Apr. 19	May 17	Oct. 22	Sept. 2	186	138	275	25

Light frosts.—A light frost, injurious only to tender plants may and frequently does occur with a recorded minimum temperature of 39° F. to 40° F. Hence the period of safe growth for the more delicate varieties of vegetation is much less than for the ordinary frost-free period. A minimum of 39° has been recorded at Philadelphia as late as May 11 (1913). The spring minimum of 39° has occurred as early as March 27 (1912) in the period between 1911 and 1925. (Table 5.)

TABLE 5.—*Light frost periods, 1911 to 1924, at Philadelphia*

Year	Latest spring date	° F.	Earliest autumn date	° F.	Days
1911	Apr. 23	37	Nov. 2	34	193
	May 3	40			183
1912	Apr. 9	36	do	39	207
	Apr. 30	40			
1913	May 11	39	Oct. 22	40	164
			Nov. 1	37	174
1914	Apr. 14	37	Oct. 25	35	194
1915	Apr. 4	30	Nov. 5	39	215
1916	Apr. 11	39	Oct. 1	40	173
			Oct. 14	37	186
1917	Apr. 25	40	Oct. 13	36	171
	Apr. 15	37			181
1918	Apr. 25	40	Nov. 7	38	196
	Apr. 13	35			208
1919	Apr. 26	35	Nov. 2	40	190
			Nov. 3	38	191
1920	Apr. 14	38	Nov. 12	29	212
	Apr. 27	42			199
1921	Apr. 19	37	Oct. 9	41	173
			Oct. 26	36	190
1922	Apr. 24	37	Oct. 19	39	178
1923	May 10	38	Nov. 1	36	175
1924	Apr. 21	40	Oct. 21	39	183
1925	do	34			

Average period free from light frost, 188 days.

Temperature changes.—Temperature conditions over a long period of time are not noticeably changing in this region. The annual mean temperatures possess remarkable uniformity. The 47 years of Pennsylvania Hospital records indicate a 53.7° mean. Weather Bureau records for 40 years following record a 54° mean. Harsh and mild winter weather prevails. Summers may be intensely hot or cool but the total amount of heat received in southeastern Pennsylvania over an extended period has not changed.

Precipitation in southeastern Pennsylvania.—After temperature, the next most important climatic factor is the moisture, either as water vapor or as water in the form of rain, snow, and the like. The rainfall determines the productiveness of a country if the temperature and sunshine are sufficient for plant life. The beneficial effects of rainfall depend upon quantity and often to an equal extent upon the time and frequency of occurrence and the rate of precipitation. As a rule, a given amount falling rapidly is of less value, agriculturally, than an equal or less amount falling more slowly.

This region has a great advantage as to rainfall, the average precipitation of 46 inches being almost ideal for agriculture. One has to be aware that only 25 per cent of the land surface of the globe receives over 40 inches annually to realize to what degree this region is favored.

Considerable variation in the mean annual rainfall of different stations is noticed. Lancaster reports 40.39 inches, Doylestown 49.22 inches, and Philadelphia 41.43 inches. The variation is probably due to position and altitude. Slight variation may be accounted for on the basis of exposure of instruments and the degree of efficiency of the recorder. (See Table 6.) The smallest amount of precipitation (28.63 inches for any one year) was recorded at Gettysburg in 1856 and the maximum amount (73 inches) fell at West Chester in 1889.

The rainfall is usually well distributed throughout the year. (Table 6.) Coatesville reports that July has the highest average, with the heaviest rainfall, 12.93 inches, also falling in that month. August in Doylestown and Philadelphia is usually the month of greatest rainfall. Most rain falls in July in West Chester, Lancaster, and York. Summer appears to be the rainy period, with the dry period coming during the fall months. Heavy rainfall sometimes occurs in May. May, 1894, was an exceedingly wet month throughout the region, Coatesville reporting 11.72 inches. May, 1903, however, was dry. Doylestown reporting a rainfall of only 0.56 inch and Philadelphia 0.93 inch.

TABLE 6.—*Precipitation: Monthly, annual, and average amounts*

Station	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Record in years
Chester Valley:														
Coatesville	3.97	4.10	4.36	3.63	4.03	4.04	5.03	4.43	3.90	3.52	3.19	4.22	48.41	
Heaviest	7.25	10.22	7.66	7.52	11.72	7.18	12.93	9.84	9.12	6.78	8.60	9.24	68.94	30
Lightest	1.36	1.03	0.49	1.38	1.19	1.46	1.16	0.46	0.71	0.48	1.01	0.59	32.70	
Snowfall	9.8	12.7	9.3	2.5	0	0	0	0	0	Trace.	2.3	7.9	44.5	
Triassic lowlands:														
Doylestown	3.66	3.86	4.07	3.98	4.01	4.00	4.86	5.53	3.95	3.98	3.30	4.02	49.22	
Heaviest	6.78	5.51	9.71	7.93	1.41	10.29	11.87	14.00	9.69	8.68	10.05	7.96	67.08	20
Lightest	1.03	1.17	0.89	1.65	0.56	1.18	0.16	1.32	0.34	0.17	0.53	1.07	31.87	
Coastal plain:														
Philadelphia	3.27	3.31	3.48	3.16	3.33	3.31	4.24	4.74	3.33	2.94	2.99	3.33	41.43	
Heaviest	6.74	6.87	9.10	9.76	9.46	8.04	10.30	12.10	12.09	66.6	7.31	7.35	55.28	
Lightest	1.49	0.84	0.38	0.61	0.54	0.74	0.75	0.46	0.20	0.30	0.67	0.83	30.21	48
Snowfall	6.7	7.5	4.5	1.2	0	0	0	0	0	0	0.8	4.8	25.5	
Trenton prong:														
West Chester	3.83	3.90	4.07	3.78	4.45	4.19	4.83	4.68	3.92	3.74	3.63	4.09	49.12	
Heaviest	7.32	7.29	8.33	8.80	13.82	9.32	14.58	12.35	12.33	8.66	9.91	8.59	73.00	
Lightest	0.81	0.47	0.52	1.10	0.83	0.96	0.73	0.55	0.29	0.36	0.74	0.59	33.03	71
Snowfall	9.7	9.1	6.8	1.5	0	0	0	0	0	0	1.7	6.9	34.7	
Limestone plain:														
Lancaster	3.25	2.68	3.45	3.54	3.28	3.99	3.92	4.08	3.34	3.08	2.42	3.41	40.30	
Heaviest	4.79	5.66	6.61	6.54	7.04	7.98	9.17	9.62	8.43	7.34	9.02	6.06	52.25	
Lightest	1.57	0.59	0.50	1.20	0.74	1.08	1.18	1.13	0.28	0.28	0.72	0.60	28.63	13
Snowfall	8.2	7.6	9.5	2.8	0	0	0	0	0	0	0.6	9.7	42.8	
Triassic lowlands:														
Gettysburg	3.14	2.81	3.16	3.60	3.97	3.90	3.62	4.07	3.37	3.20	2.67	3.33	40.84	
Heaviest	7.22	7.11	8.00	6.09	10.95	8.58	9.08	12.99	8.71	7.57	8.48	6.08	52.25	
Lightest	0.63	0.98	0.48	0.62	1.10	0.26	0.85	0.45	0.72	0.56	0.38	0.60	28.63	20
Snowfall	12.0	9.8	7.8	1.9	0	0	0	0	0	0	1.6	9.7	42.8	

Between the years 1900 and 1919, inclusive, Lancaster, Philadelphia, and West Chester report the following critical monthly rainfall conditions. (See Table 7.)

TABLE 7.—*Number of days with monthly rainfall as indicated, 1900–1919, 20 years*

[(1) Lancaster, (2) West Chester, (3) Philadelphia]

Critical months	1 inch or less	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 8	8 to 10	Over 10
March (1)	2	3	3	5	5	2	0	0	0
(2)	1	1	2	4	7	4	0	1	0
(3)	2	0	6	5	4	2	0	1	0
April (1)	0	2	5	9	2	2	0	0	0
(2)	0	0	6	7	4	1	1	1	0
(3)	0	2	6	6	5	0	1	0	0
May (1)	2	2	7	5	3	1	0	0	0
(2)	0	3	2	4	6	4	1	0	0
(3)	2	2	6	0	6	2	2	0	0
June (1)	0	2	5	3	3	4	3	0	0
(2)	0	1	3	5	4	1	6	0	0
(3)	0	3	9	2	1	3	1	1	0
July (1)	0	2	2	5	4	2	4	1	0
(2)	1	0	4	4	3	3	3	0	2
(3)	0	1	3	6	5	3	1	0	1
August (1)	0	3	4	7	1	0	3	2	0
(2)	0	3	3	0	2	4	5	2	1
(3)	1	2	2	4	2	3	2	3	1

The normal rainfall is ample for the growing of the staples of the area. The annual rainfall if well distributed would be sufficient even in the driest year, but occasionally there exists a marked seasonal deficiency or excess, either of which may be detrimental, particularly the former. During some seasons of the year this scarcity of rain is comparatively unimportant, but during periods of critical crop growth it becomes a question of serious moment.

Dry spells.—Dry spells are most frequent after the harvest season in the autumn months of September, October, and November. In consecutive periods of seven days or over the Weather Bureau records at Philadelphia between the years 1872 and 1924, inclusive, show the total number of days with a rainfall of less than 0.01 of an inch to be divided among the months as indicated in Table 8. The autumn dry spell of 1914 was especially noticeable—less than 0.01 of an inch of rainfall from September 3 to September 23, a period of 21 days.

TABLE 8.—*Number of consecutive days in periods of a week or more with less than 0.01 inch of rain*

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
39	96	89	181	220	135	109	173	209	274	182	101	1,808

After a short break dry weather began on the 26th and lasted until October 14, making a total period of 40 days with practically the minimum of rain. In this period of drought the rivers were very low and the ground exceedingly dry. In 1910 only 0.01 inch of rain fell between September 7 and October 6, a period of 30 days. Rainfall in May at Lancaster has been below normal 14 times in the last 21 years. Only twice, however, has less than one inch fallen at Lancaster during May in a 21-year period. During those years (1902–1923) there were 36 consecutive days in the May months with a rainfall of 0.01 inch or less at Philadelphia. Although the May month of these two years was dry, its effect was somewhat modified by heavy winter rains and normal March and April precipitation. In each case also the summer period was extremely rainy. Rainfall during the summer of 1902 was 3.34 inches above normal, and 5.89 inches excessive rainfall fell in 1903 at Lancaster. Droughts as they occur in more westerly States are unknown and where the land is in really good tilth, crops usually weather even the driest spells. Land not in good tilth and land of uncertain types on exposed slopes suffer during the dry period. Dry spells that do a great deal of damage occur on an average of only two or three times in a decade. Total crop failures are even then usually prevented by timely showers.

Wet spells.—Rain or snow storms do not usually exceed two or three days in duration. There are frequently periods, however, of much more extended rainy or cloudy weather.

On August 3, 1898, there was in Philadelphia a rainfall of 5.48 inches in two hours and 5.89 inches in the 24-hour period. The lightning was terrific and many buildings were struck.

A large number of sewers burst and many cellars were flooded. Between May 21, 1897, and September 6, 1910, the Philadelphia office has recorded 66 storms with excessive precipitation.[4] Excessive rains in summer are usually accompanied by thunderstorms. These occur most frequently in the month of July. June and August are close rivals. Between 1885 and 1910, July has averaged seven thunderstorms (not all, however, carrying excessive precipitation). In the year 1905, 51 thunderstorms were recorded. Thirteen thunderstorms in July (1901) and the same number in July, 1902, were the greatest number recorded in any one month.

An interesting comparison of the frequency of days with thunderstorms in 12 representative cities of the United States is made in Table 9. Only three cities, Boston, Mass., New York, N. Y., and Los Angeles, Calif., had fewer days with thunderstorms annually than Philadelphia between the years 1904 and 1923.

TABLE 9.—*Frequency of days with thunderstorms in 12 representative American cities, 1904–1923* [1]

City	Number of days with thunderstorms (yearly average)	City	Number of days with thunderstorms (yearly average)
Baltimore	34	Los Angeles	4
Boston	19	New Orleans	74
Chicago	41	New York	31
Cincinnati	50	Philadelphia	33
Cleveland	38	Pittsburgh	46
Detroit	38	St. Louis	50

[1] Alexander, W. H.: Distribution of thunderstorms in the United States. MONTHLY WEATHER REVIEW, 52, 337-343.

Although the thunderstorms in July are most numerous, the August storms produce greater rainfall per storm. In 50 years (1874–1924) there were 10 storms in July with a precipitation of 1 inch or over an hour. The average was 1.285. In the same period August recorded 25 such storms with an average precipitation of 1.5796. The greatest precipitation in one hour also occurred in August when 5.43 inches of rain fell on August 3, 1898. This probably indicates a greater severity of the August thunderstorms. June in the same period produced only seven such thunderstorms with the greatest precipitation being 1.90 inches, September recorded 11 with a maxi-

[4] Precipitation is excessive if greater than 1 inch in two hours or 0.50 inch in 30 minutes.

mum precipitation of 2.43 inches per hour. Eight storms were divided as follows:

Month	Number	Maximum amount of precipitation per hour
February	2	1.11
April	1	1.68
May	4	1.38
October	1	1.53

Summer rains are less than half the duration of those of the winter. February is the winter month with excessive precipitation occurring within an hour. February 28, 1902, witnessed a storm in which 0.97 inch fell in half an hour and a total of 1.36 inches fell between 7:40 a. m. and 4:15 p. m. February rains are of the cyclonic type as compared with the convectional rains of the summer months. Floods are most common in February and March when the ground is frozen or has been saturated by previous rains. Flood damage is not extensive, however, except along the meadowlands and low river terraces. On October 23, 1878, during a heavy windstorm, the truck farms and bottom lands were flooded by backwater from the Delaware River and Bay, the water attaining the highest point in more than 80 years. Ice freshets during the winter and spring months and heavy rains in the summer will, at times, increase the Schuylkill River at Manayunk above ordinary low-water mark as much as 27 feet (1869) and 21 feet (1894). Floods of this height will cause property damage in river towns, destruction of bridges, and flooding of river bottoms. No floods, such as are experienced along the Ohio and Mississippi Rivers, occur in southeastern Pennsylvania.

Narrow river valleys with little level land and limited drainage basins adjoining make floods harmless when compared with the great floods of the Middle West.

Snowfall.—Precipitation is largely in the form of rain. The mean annual snowfall for nine scattered stations throughout the region is 35.4 inches. This is a comparatively light snowfall. Coatesville reports the largest annual snowfall and Philadelphia the least. During a 30-year period, 44.5 inches of snow has fallen annually in Coatesville and 25.5 inches at Philadelphia. Grampian (central Pennsylvania) reports 72.7 inches average per year, and Montrose (western Pennsylvania) reports 71.6 inches. A large part of the winter precipitation is rain or rain and snow mixed. Occasional heavy snows occur as on March 12, 1888, when 10 inches of snow fell and in the night of December 25, 1909, when there was a snowfall of 21 inches in Philadelphia. The greatest depth of snow on the ground in Philadelphia was 26 inches in 1899. In contrast, the year 1901 had only 3 inches on the ground at any one time. The total snowfall of that year was only 11.4 inches. The least snowfall was during the year 1889 when a total of 5.7 inches fell in Philadelphia, and the greatest in 1907 (44.6 inches). Most of the snow falls during the months of January and February. These months are closely followed in amount by March and December. Only infrequently does the snow remain for an extended period as a blanket covering the ground.

Frequently the daily temperatures rise above freezing, even in midwinter, and the winter rains soon transform the snow into slush.

Hail and wind storms.—Hailstorms and severe windstorms of tornadic nature are not common in this region and where they do appear are greatly restricted in extent. They have been known, however, to do very serious local damage. The Evening Public Ledger of Tuesday, June 16, 1925, reported that two deaths and damage of more than $20,000 resulted from a sharp electrical storm that broke over the city of Chester early that same day. It also states that in the western part of the city the roofs of a dozen houses were blown off, the window of a department store broken by the wind, and scores of persons hurt by hailstones. The wind was estimated to have had a velocity of 60 miles an hour. Between the years 1911 and 1916, inclusive, the Philadelphia Weather Bureau reported six days with hail, one each in February, May, June, July, August, and November.

The records for the years 1911 to 1924, inclusive, show an average of 78 days per year with a wind velocity of 25 miles or over, but only a 3½-day yearly average with wind velocity over 40 miles. January heads the list, followed by March and August. The heavy winds are mostly of the winter and spring varieties and are the result of the greater development of the pressure areas during the winter months. The August winds are more the result of unequal local heating and usually accompany thunderstorms. A velocity of 75 miles per hour was experienced only once in 39 years, and a velocity of 60 miles an hour or over was recorded five times. Velocities of over 40 miles per hour in the same period occurred on 114 different occasions.[5]

HUMIDITY AND FOGS

Humidity, the invisible moisture of the atmosphere, has important functions to perform. It tempers the heat and cold. Extremes of temperatures do not prevail where humidity is present in large amounts. It is the great source of supply of precipitation. It is also at times a source of personal discomfort. High relative humidity with a high temperature causes the air to feel muggy and man to lose energy through the prevention of rapid evaporation. High humidity plus a low temperature produces a raw atmospheric condition. A moderate temperature becomes oppressively hot when the humidity approaches or exceeds 80 per cent. Temperatures of 15° or 10° above zero with an 80 per cent humidity, a condition fairly common in this region, causes much suffering. Temperatures, however, of 20° below zero with a humidity of 25 to 30 per cent are described as comfortable and exhilarating in the Northwest.

Humidity is rather high at frequent intervals in southeastern Pennsylvania. During May, 1925, the relative humidity at 8 a. m. reached 80 per cent on 10 days out of the 31. On the 24th at 8 p. m. the relative humidity was 97 per cent and on the 29th it stood at 92 per cent. The mean for the month was 73 per cent at 8 a. m. The normal monthly means are indicated as follows:

Month	8 a. m.	8 p. m.	Month	8 a. m.	8 p. m.	Month	8 a. m.	8 p. m.
January	76	70	May	71	65	September	78	70
February	74	68	June	72	66	October	76	67
March	73	65	July	72	66	November	75	67
April	66	60	August	75	68	December	74	67

Mean annual relative humidity conditions of approximately 70 per cent divided, as indicated above, makes for many raw winter days and hot, oppressive summer days during the year in this neighborhood. August,

[5] A gale is technically defined as a wind velocity of 40 miles or over per hour.

with a 75 per cent average at 8 a. m. and a 68 per cent average at 8 p. m., is our most disagreeable month, while on many a January day the damp cold penetrates through the warmest of garments even with the temperature above zero.

Fogs of some nature are fairly common in this region during the months of November, December, and January. October, 1899, experienced eight days with fog, the greatest number of foggy days of any monthly period (1885–1910). The mean monthly (1871–1910) fog record is as follows:

January	1.30	May	0.1	September	0.8
February	.80	June	.2	October	.9
March	.70	July	.2	November	1.2
April	.30	August	.4	December	1.2

Dense fogs, however, are not of long duration, rarely continuing through any considerable portion of the day period. At times, however, they are a serious menace to shipping along the Delaware and to highway transportation throughout the entire region. Fogs do not interfere with plant growth for there is usually an abundance of sunshine during the growing season all through the region. The amount varies considerably in different months, but in all months the average is 59 per cent of the possible amount divided among the months as follows:

	Per cent		Per cent		Per cent
January	51	May	59	September	64
February	59	June	61	October	62
March	54	July	64	November	54
April	58	August	63	December	53

SUMMARY

The climate of this region may be considered as a modified marine type due to its proximity to the Atlantic Ocean. Throughout the largest and most important part of the region under discussion conditions approach the climatic mildness of the States of New Jersey, Delaware, and Maryland. Altitude and oceanic influences are responsible for this section of the State having milder temperature conditions than prevail elsewhere in Pennsylvania. The Erie plain on account of its close proximity to the lake has a mean temperature and a growing season of greater similarity to this region than to any other part of the State.

Southeastern Pennsylvania from a climatic point of view is the most favored part of the State for the development of a diversified agriculture. Its rainfall of over 45 inches, well distributed throughout the year, is well above the average for the State. The growing season is the longest, the winters are the mildest, and the danger of droughts less than any other part of Pennsylvania. The summer heat and humidity is excellent for the rapid development of plant life. Few storms of tornadic violence prevail and the crop damage is very small. Oppressive heat due to the high humidity makes many days disagreeable to man and beast in summer and the presence of many raw days in winter on account of the same high humidity modifies the mildness of the winter period. All things considered, however, the area possesses an exceptionally advantageous climate for the development of man, on the farm, in the factory, and at home.

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SEVERE COLD WAVES ON THE TEXAS COAST

By I. R. TANNEHILL

[Weather Bureau office, Galveston, Tex., February 25, 1928]

Severe cold waves on the coast of the Gulf of Mexico are infrequent but of great moment. Human habitation and dress are not here adapted to extreme cold; cattle and other livestock are inadequately sheltered from winter extremes, and tropical fruits and winter truck are subject to extensive damage and occasional total destruction from abnormally low temperatures. In economic loss and human suffering, a severe cold wave, reaching our southern and southeastern borders, ranks with the hurricane.

Bennett (1) and Mitchell (2) have treated of cold waves in Florida briefly. The former, as a result of a study of 51 occurrences of freezing temperature at Tampa, has noted the distribution of barometric pressure necessary for extreme cold in that section. Cox (3) has discussed cold waves in the United States and has presented a number of precepts for forecasting their movements. Garriott (4) assembled numerous maps typifying cold-wave conditions and added a discussion, chiefly historical. His collection of maps forms a valuable reference background for any cold wave study.

Aside from these, there have been numerous notes, mostly reviews of individual cold waves. The subject is sufficiently important to merit a more extensive literature. Few explanations have been offered for the failure of numerous intense high-pressure areas to carry the cold to certain sections. Cold-wave warnings, now and then, fail completely of verification and the causes apparently are imperfectly understood. There are so many factors influencing the movement of cold waves and the complexities of the subject seem to be endless.

Cox, in concluding his remarks on cold waves, (3) says:

> It is obvious that the degree of cold recorded in a cold wave depends upon the intensity of cold in the HIGH and the temperature of the LOW in front of the HIGH, the magnitude of the HIGH, the barometric gradient between the HIGH and the LOW and the consequent wind force, the direction of movement of the HIGH and also the LOW or LOWS which it is following, the general character of the sky, the humidity, whether there is snow on the ground, and the season of the year; in a word, all the atmospheric conditions, sometimes even within an area of 3,000 or 4,000 miles or more.

In a treatment of cold waves that have visited the west Gulf coast area, one is concerned with atmospheric conditions over the continent and neighboring oceans. With a full realization of these difficulties, the writer attempts a description of severe cold waves in the area named, with an explanation of some cold-wave failures, together with criteria for forecasting temperature minima. Some of these rules may prove helpful. None is infallible.

Frequency of severe cold waves.—A cold wave in the winter months, in the coast section of Texas, is defined by the Weather Bureau as a fall in temperature of 16° in a 36-hour period to a minimum of 32°. The severe cold waves discussed in the following have all far exceeded these limits both in rapidity of fall and in intensity of cold. Just what degree constitutes a severe cold wave is difficult to determine, but for the purposes of this paper, a fall of 20° to a reading below 25° is considered severe and a fall of 30° or more to a minimum below 20° is considered very severe.

In the 57 years of record at Galveston, 1871 to 1927, inclusive, there have been 27 cold waves with temperature below 25°. These include the cold wave of January, 1928, which set in on December 31, 1927, and reached a minimum of 20° on January 2. Also included as separate cold waves, are those of 1886, 1887 and 1895, which came in pairs with short intermissions. Strictly, there were only 23 instances, as shown in Table 1. In seven, the temperature fell below 20°, counting the pair in 1895 as a single occurrence.

TABLE 1 [1]

Year	Central date of cold wave	Temperature, minimum	Year	Central date of cold wave	Temperature, minimum
		°F.			°F.
1873	Jan. 29	21	1894	Jan. 26	24
1875	Jan. 10	24	1894	Dec. 28	21
1879	Jan. 6	23	1895	Feb. 8	15
1879	Dec. 26	24		Feb. 16	19
1880	Dec. 29	18	1897	Jan. 27	21
1883	Jan. 21	20	1899	Feb. 12	8
1884	Jan. 7	22	1903	Feb. 17	24
1885	Jan. 17	23	1905	Feb. 13	17
1886	Jan. 8	11	1910	Feb. 18	24
	Jan. 12	21	1911	Jan. 3	19
1887	Jan. 3	24	1912	Jan. 12	20
	Jan. 10	24	1918	Jan. 11	16
1888	Jan. 16	23	1928	Jan. 2	20

[1] Dates of cold waves with minima below 25° at Galveston during years 1871 to 1927, inclusive. The first three in parentheses were in reality continuations of the preceding waves and were of little importance. The last occurred in 1926, but the cold set in at the close of 1927.

In some of these cold waves the temperature remained below the limits shown for more than one day. The number of days with temperatures below certain limits is shown in Table 2. For years prior to 1875 there are no records of daily minima.

TABLE 2 [1]

(1)	(2)	(3)	(1)	(2)	(3)
32	177	3.34	20	12	.23
31	153	2.89	19	10	.19
30	120	2.26	18	9	.17
29	102	1.92	17	7	.13
28	77	1.45	16	5	.09
27	66	1.25	15	3	.06
26	54	1.02	14	3	.06
25	38	.72	13	3	.06
24	27	.51	12	3	.06
23	22	.42	11	2	.04
22	18	.34	10	1	.02
21	15	.28	9	1	.02

[1] (1) Temperature limit. (2) Number of days in period 1875 to 1927, inclusive, with temperature *below* degree shown in (1). Months of December, January and February only considered in this table. (3) Average annual number based on this 53-year record.

Probable minima in certain periods have been computed from Marvin's formula for standard deviation and the average interval curve of Spillman, Tolley and Reed (5). The results are shown in Table 3. The actual intervals as averaged from Galveston's record are also given. The frequency of low temperatures is somewhat greater than indicated by the theory of probability. With lower temperatures the discrepancy increases. This is evidently due to slight lack of symmetry in the frequency distribution. Departures below the mean are fewer and of greater average magnitude than those above the mean. Both by experience and the theory of probability based on that experience, the frequency of years with minima below 20° is about one in eight, roughly.

TABLE 3 [1]

(1)	(2)	(3)	(1)	(2)	(3)
5	20.9	5.7	50	13.5	28.0
10	18.2	9.3	100	11.8	28.0
25	15.4	18.7	150	10.9	56.0

[1] (1) Interval in years. (2) Probable minimum in interval shown at left computed from standard deviation and average interval curve. (3) Actual average intervals between occurrences of minima shown in column (2). Record, 56 years at Galveston, Tex.

The frequency of cold waves with temperatures below 25 is slightly greater at Corpus Christi than at Brownsville. The lowest temperature in all cold waves with readings below 25° at either Corpus Christi or Brownsville is given in Table 4. Extremely low temperatures have not been so frequent on the south Texas coast as at Galveston. The temperatures marked with an asterisk in the table are in doubt, but it seems quite probable that the temperature in both instances fell below 25° at Brownsville.

TABLE 4 [1]

Year	Brownsville minimum and date	Corpus Christi minimum and date	Galveston minimum and date
1880	18 Dec. 30	(2)	18 Dec. 29
1886	22 Jan. 9	(2)	11 Jan. 8
1887	26 Dec. 22	24 Dec. 22	29 Dec. 22
1888	21 Jan. 16	16 Jan. 15	23 Jan. 16
1895	22 Feb. 8	18 Feb. 8	15 Feb. 8
1897	(2)	22 Jan. 27	21 Jan. 27
1899	12 Feb. 13	11 Feb. 12	8 Feb. 12
1901	20* Jan. 1	32 Jan. 1	40 Jan. 3
1901	15* Dec. 15	20 Dec. 15	25 Dec. 15
1905	22 Feb. 13	18 Feb. 13	17 Feb. 13
1909	28 Jan. 12	24 Jan. 12	28 Jan. 12
1911	21 Jan. 4	21 Jan. 3	19 Jan. 3
1912	24 Jan. 13	23 Jan. 13	20 Jan. 12
1917	24 Feb. 2	26 Feb. 2	26 Feb. 2
1917	24 Dec. 30	24 Dec. 30	26 Dec. 30
1918	25 Jan. 11	20 Jan. 12	16 Jan. 11
1919	24 Jan. 4	30 Jan. 4	28 Jan. 4
1924	26 Dec. 21	23 Dec. 20	28 Dec. 20
1925	26 Dec. 28	24 Dec. 28	26 Dec. 28

[1] Temperatures below 25° at Corpus Christi and Brownsville, with dates and minima at Galveston for comparison. All dates of minima below 25° are not given—only the lowest in each cold wave. For Galveston's complete data, see Table 1.
[2] No record.

*Temperatures seem too low; see discussion in text.

In several cold waves the temperature has been lower on the south Texas coast than at Galveston and the conditions obtaining in the two cold waves of 1901 were of the character that cause colder weather in the lower Rio Grande Valley than on the east coast. The cold wave moves well southward and eastward before the low-pressure area in the extreme south leaves the vicinity of the Rio Grande Valley, moving eastward, usually with diminishing energy. Northwest winds, clear skies, and lower temperatures prevail in the Rio Grande Valley, while the wind continues to blow from the north and northeast on the east coast with overcast sky. When the southern depression moves eastward and northeastward with marked increase in energy before the cold wave has penetrated far to the southward, as in 1886, 1895, and 1918, it is much colder at Galveston.

The fall in temperature.—From highest temperature on one day to lowest of the following, falls in excess of 50° have not been rare on the Texas coast. When the fall, in a precise span of 24 hours, from any hour to another of the same name, exceeds 40°, the cold wave is uncommonly severe. In January, 1918, at Galveston, the 24-hour fall amounted to 42°. In 12 hours, from 11 p. m. of the 10th to 11 a. m. of the 11th, the temperature fell from 63° to 16°, or 47° in 12 hours, and at the latter hour it is normally warmer in January than at 11 p. m. Ahead of cold waves in extreme southern Texas the temperature sometimes rises almost to midsummer heat. On December 13, 1901, the temperature at Corpus Christi rose to 86° and at 7 a. m. of the following day stood at 36° and on the 15th dropped to 20°. It seems doubtful that the greatest changes in northern latitudes, necessarily taking place at lower temperature levels, can so profoundly affect human comfort.

In January, 1886, at Galveston the temperature fell from a maximum of 65° on one day to a minimum of 11° on the following day, a drop of 54°. Such temperature drops are, however, decidedly unusual. Due to the greater diurnal range in temperature, such marked changes from the high temperature of one day to the low of the next are somewhat more common in the interior.

The cold wave, however, is generally but one single violent fluctuation in the midst of a depression of temperature extending over a period of many days. Its southward sweep is usually facilitated by cold waves of lesser proportions preceding. Figure 1 indicates graphically the average march of temperature during the 15 days preceding and 15 following the date of greatest depression in seven severe cold waves. There is evident a deficiency accumulating irregularly through a period of 15 days and a recovery in the same period from and to temperatures approximately normal. A preliminary drop appears on the fourth and fifth days preceding, about the average interval between low pressure areas.

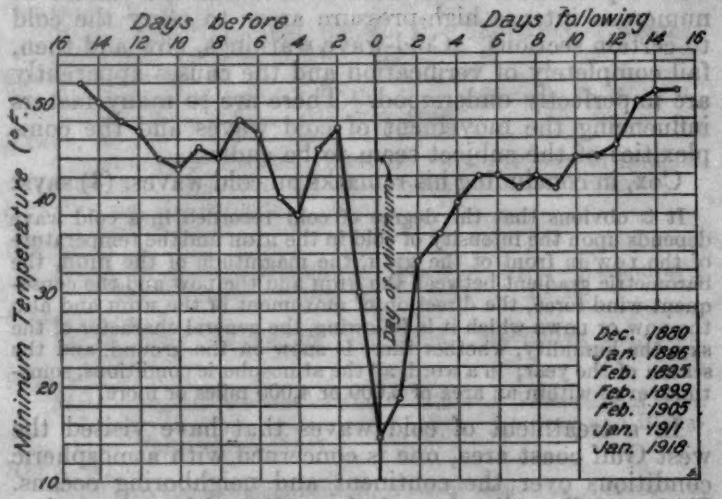

FIG. 1.—Average trend of daily minimum temperatures 15 days preceding and 15 following central date of lowest temperature in seven most severe cold waves at Galveston

The average hourly fall in temperature is shown in Figure 2 for five of the seven severe cold waves. There are no hourly records for the years 1880 and 1886. The minimum is reached in 28 hours after the initial decline. In every instance a temperature within 4° of the minimum was recorded within 30 hours. Counting from the time the temperature begins to fall, it is safe to conclude that only a slightly lower temperature is yet to occur than the minimum of the first 30 hours.

Diurnal variations and the time of day the cold wave arrives are the chief influences in determining the time of occurrence of the minimum. Diurnal effects are exhibited in Figure 3. These are averages of 23 cold waves. Those marked "A" arrived between 6 p. m. and midnight, "B" between noon and 6 p. m., "C" between 6 a. m. and noon and "D" between midnight and 6 a. m. In the two classes arriving before noon of the first day, the minimum occurred on the morning of the second day and

in the two classes arriving after noon of the first day the minimum occurred on the morning of the third day. All showed a definite upward trend in the forenoon of the

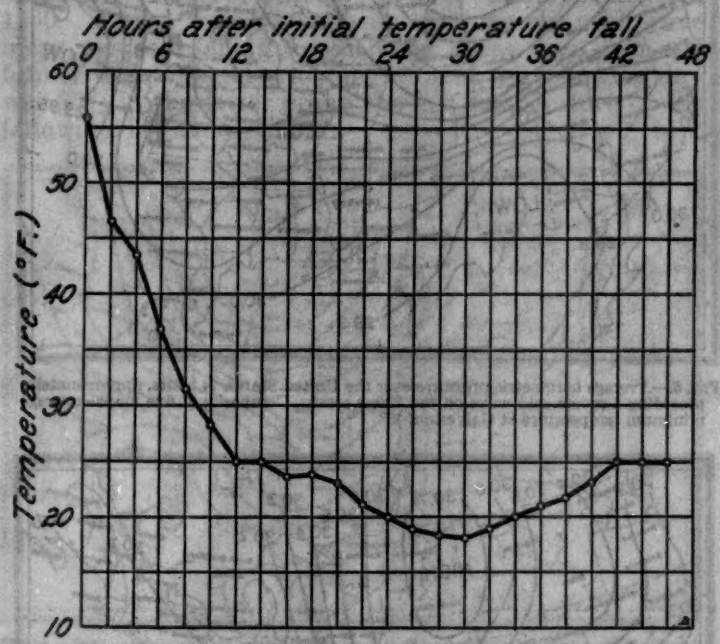

FIG. 2.—Average hourly temperatures in severe cold waves, with minima below 20°, at Galveston. Average temperature at hour of arrival, "0", and each hour thereafter for a total of 48 hours. Average minimum 15°, due to varied interval between arrival and occurrence of minimum temperature, the lowest of the average hourly temperatures is 19°

third day. The minimum tended to occur progressively earlier in harmony with the time of arrival but the diurnal change shifted the occurrence to the early morning hours.

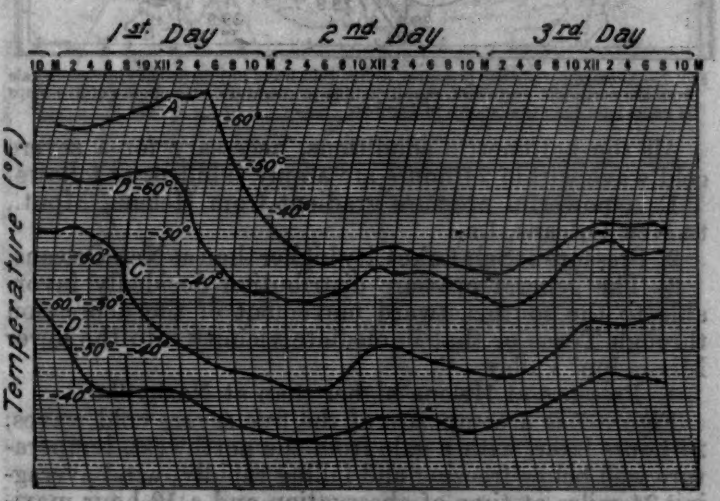

FIG. 3.—Average hourly temperatures in 23 cold waves, 1911 to 1930, inclusive. A, Average for seven cold waves arriving between 6 p. m. and midnight; B, for six cold waves arriving between noon and 6 p. m., C, for six cold waves arriving between 6 a. m. and noon; D, for four cold waves arriving between midnight and 6 a. m.

By averaging the hourly temperatures in the entire group of 23 cold waves, the diurnal variation is largely eliminated and the minimum is found 24 to 30 hours after the initial fall in temperature. This agrees with the findings in the case of the severe cold waves, only two of which are included in the group of 23.

Cloudiness, of course affects the amplitude of the diurnal variation as well as its general character. Differences in the distribution of cloudiness over the State produce peculiar effects. When the weather continues cloudy on the coast but clears in the northern portion of the State the morning minimum is greatly delayed as the cold air from the interior underruns the clouds and its temperature therefore does not rise. In the early night the air from the interior, now warmed by the sun, passes underneath the cloud bank, and, losing little heat through radiation, retards the maximum temperature. It is then sometimes colder at midday than at sunrise and the temperature remains persistently high far into the night. A knowledge of these diurnal influences is essential in order to place accurately the occurrence of minimum temperature.

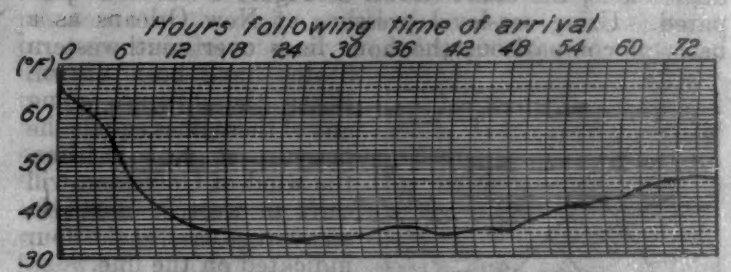

FIG. 4.—Average hourly temperatures in 23 cold waves, 1911 to 1930, inclusive, dating from the hour of initial temperature fall. The time of arrival is "0" hour

Conditions are very favorable when the cold wave arrives early in the day and cloudiness continues until sundown, followed by clearing. In this connection Cox (3) remarks:

> When a cold wave threatens any point, a cloudy sky which prevents the temperature from rising during the day is much more favorable for the verification than when the day is clear, because in that case, the journey to the verifying point will not be so long as if a comparatively high maximum were reached. So also are the chances for verification much better if the ensuing night is clear so that radiation may be free.

Origin of Texas coast cold waves.—The anticyclone bearing winds of the Texas coast cold wave is of the type known as an "Alberta High." It develops over an area embracing the western portion of North Dakota and Montana or, as is more frequently the case, moves in a southerly direction from the British northwest, crossing the Canadian border into that area. The cyclone preceding it develops over Texas, Oklahoma, or northern Mexico or moves through that region from the southern Rockies. Yet it is well known that many strong high-pressure areas have moved into the former area and numerous energetic cyclones have passed through the latter region without producing severe cold waves on the Texas coast. The two, in combination, cause the cold wave, and their movements must be favorably timed. At any stage in the progress of the high and cold wave, there are unfavorable positions for the LOW[1] and, in those situations, the HIGH either blocks the forward movement of the cyclone and the vigorous circulation of the latter opposes the cold winds of the former, or, the cyclone moves too rapidly, drawing the cold to other regions.

When a strong HIGH is advancing into Montana and western North Dakota, a severe cold wave may set in over the Texas coast within 24 hours provided the low-pressure area is favorably situated. It is important, then, that the average movement of southwestern LOWS be accurately known.

According to Bowie and Weightman (6) the average movement in winter is about 750 miles per day. In order that the center of the cyclone may advance far enough to the eastward, in 24 hours, to cause the wind to

[1] The author uses the terms "low" and "cyclone" interchangeably.—*Ed.*

shift on the Texas coast, its position, according to this calculation of average movement, must not be farther west than a line joining Denver, Santa Fe, and El Paso, roughly. In order that its movement may proceed at least at a normal rate, the pressure exerted upon its front must not exceed that upon its rear (7), hence, since its movement must carry it toward the lower Mississippi Valley, the pressure there must not exceed that along a line from Salt Lake City to Modena and along the western border of Arizona.

From a study of the movement of 102 southwestern depressions, the chart shown in Figure 5 has been prepared. Using sea-level pressure at New Orleans as a basis of comparison, the hour lines over southwestern States have been drawn. When the pressure along any of these lines equals the pressure at New Orleans, the wind at Galveston will shift to west or north, in an average case, at the hour indicated on the line.

FIG. 5.—When pressures along any line in above chart equal pressure at New Orleans, La., the wind at Galveston will shift to northerly or westerly at hour indicated on line. Low-pressure area must be centered in southern Rockies. When pressure at Helena, Mont., is lower than New Orleans wind will likely shift to southwest or west and when higher to northwest or north

This device has an advantage over the use of the low-pressure center and its average movement, because it takes into account both the location of the center and the pressures exerted upon it.

Pressure indications of severe cold wave.—When the cyclone is over the southern Rockies, pressure must be high in the far Northwest. Relatively low pressure in Montana is at this stage indicative of failure to reach the Texas coast. High pressure in the northern plains normally in 24 hours moves in winter to the upper Mississippi Valley, western Lakes or thereabouts (8). With the crest of the HIGH in the latter region, a cold wave is not likely. The center of the LOW must then be passing through the west Gulf region or the lower Mississippi Valley, unless pressure continues very high in Montana or shows immediate signs of reinforcement.

When a powerful cold wave is sweeping across the Texas coast, a barometric gradient of about 1 inch usually obtains between the northern plains and the lower Mississippi Valley. Great pressure differences between these regions are essential. Therefore, indications must point to a maintenance of high pressure in the northern plains until the LOW in the southern Rockies has moved eastward or southeastward into the lower Mississippi Valley or thereabouts. Any indications of weakening of this pressure in the north before the LOW passes out point to probable failure of the cold wave.

Figure 6 is an isobaric chart, a composite of five, immediately preceding five very severe cold waves reaching the Texas coast, those of 1886, 1895, 1899, 1905, and 1918. Averages of barometric pressures for representative stations, some interpolated from published charts, were used. Approximately 24 hours later, in each instance, a severe cold wave was in progress. The preceding cyclone, having drawn cold air southward and eastward, is evident in the far Northeast. The second cyclone overlies the southern Rockies and a strong high-pressure area is moving southeastward from the British northwest.

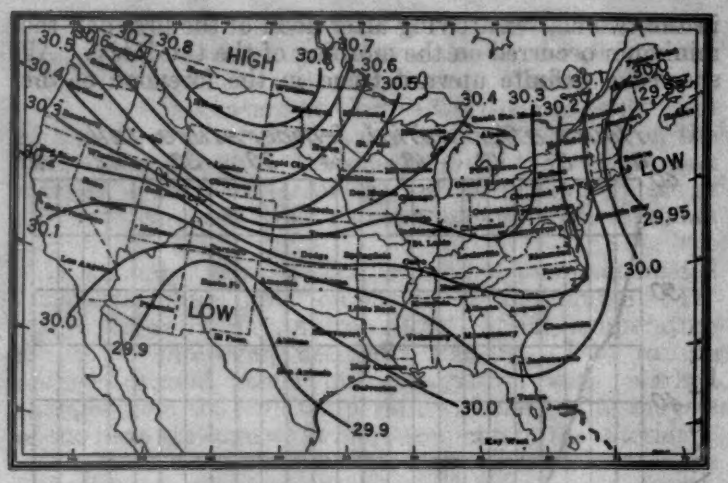

FIG. 6.—Average barometric pressures over the United States, 24 hours, approximately, preceding a severe cold wave on the Texas coast. Composite of five maps—average minimum temperature at Galveston, 13°

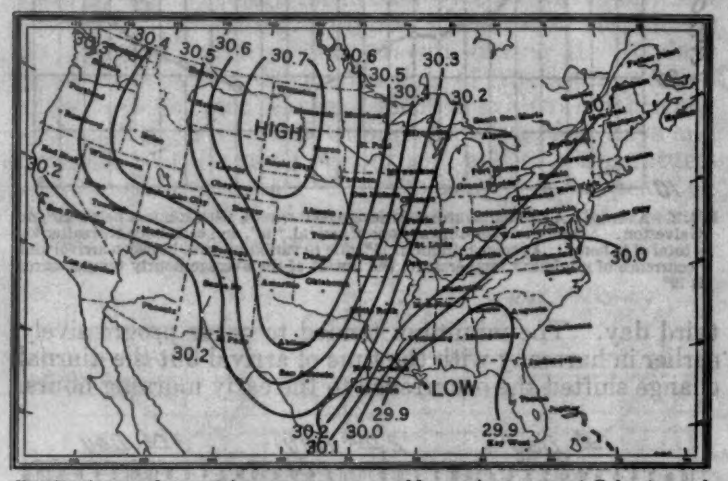

FIG. 7.—Average barometric pressures, severe cold wave in progress at Galveston; gale from the north and northwest, rapidly falling temperature. Composite of five maps 24 hours later than that shown in Figure 6

All the barometric conditions, necessary for a severe cold wave within 24 hours are amply fulfilled, as follows:

1. A powerful pressure gradient from Helena, Mont., to New Orleans, La.
2. Pressure at Salt Lake City higher than at New Orleans.
3. The general pressure distribution decidedly favorable to the southeastward movement of the depression through Texas or that immediate vicinity into the lower Mississippi Valley.
4. Pressure at Helena higher than at Nashville.

Figure 7 is a composite of the five severe cold waves, 24 hours later, with a gale from the northwest, temperature well below freezing and falling rapidly, wind averaging 34 miles at time of observation and a 12-hour maximum averaging 41 miles per hour.

The pressure gradient from North Dakota to southern Louisiana now averages more than 0.80 inch. A powerful indraught of cold takes place through the plains region into West Gulf States. Pressure is relatively high in the Southwest. The crest of the northern HIGH, or center of divergent winds is far to the northward and the cold air is drawn from high latitudes.

From Garriott's collection of cold-wave maps in Bulletin P, (4) I have selected the six cold waves producing the lowest temperatures at Galveston on the following day: December 27, 1894; January 18, 1892; January 23, 1894; February 11, 1894; February 6, 1895; and February 11, 1899. The composite isobaric chart for the six is

Figure 8. The six most conspicuous failures to produce cold waves on the Texas coast on the following day were: December 12, 1893; December 2, 1897; January 3, 1890; December 16, 1897; February 6, 1893; and February 25, 1890. Figure 9 is a composite of these six cold wave maps, the cold failing to reach the Texas coast. In the former the average low temperature of the following day was 20°; in the latter group the low temperature of the following day averaged 52°.

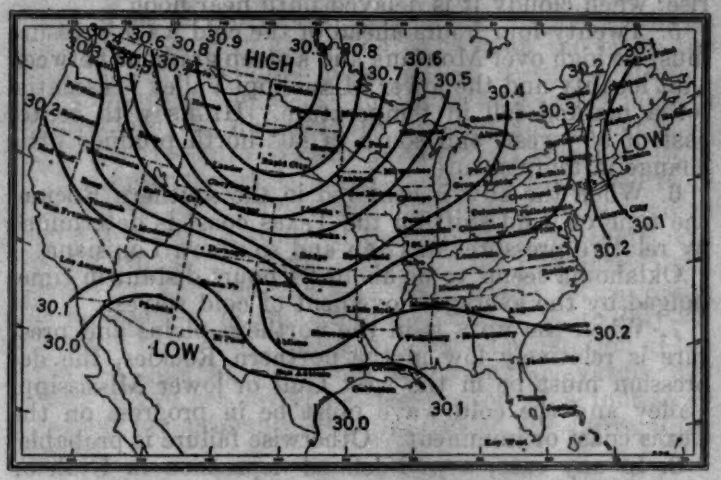

FIG. 8.—Composite map—six severe cold waves in 24 hours at Galveston; from Garriott's collection, Bulletin P

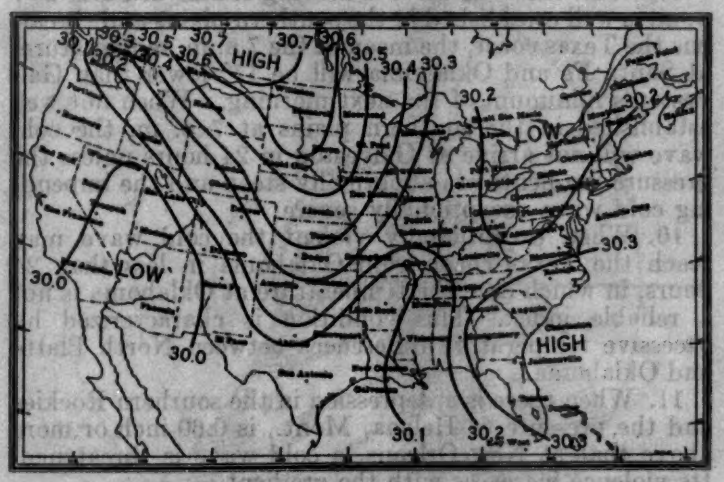

FIG. 9.—Composite of six maps, Garriott's collection; most conspicuous failures to produce cold on Texas coast within 24 hours

In the first series the barometric conditions are fulfilled; in the latter group the gradient, Helena to New Orleans is only about 0.30 inch; the pressure at Salt Lake City is lower than New Orleans, indicating that for nearly 24 hours, at least, the southwestern LOW will oppose the southward advance of the HIGH.

Within 24 hours conditions may change and in some of these instances there was a change with cold weather ultimately reaching the Texas coast. The weather map of the following morning indicates these changes. So far as a severe cold wave is concerned the critical pressure gradient is that from the Rocky Mountain region, Helena, Salt Lake City, and Denver, approximately, on the one hand, and the lower Mississippi Valley on the other.

In short, the cold wave is produced by high pressure and low temperature in the northern plains and low pressure in the lower Mississippi Valley. Preceding this condition by 24 hours, then, the southwestern LOW must be in a position to pass eastward of the Texas coast and pressures exerted upon it must be favorable for such a movement. The barometer must be high *to the westward* of the northern plains region so that high pressure in the latter area will be maintained until the LOW has passed eastward. A well-defined LOW centered in the region about Utah or Nevada is a decidedly unfavorable condition.

It is understood, of course, that barometric tendency at time of report is to be taken into consideration; in all cases the 12-hour pressure changes should be considered.

The minimum temperature forecast.—The minimum reached depends of course on the distribution of temperature over the plains and Rockies as well as barometric pressure and the intensity of indraught of cold from the north. In seeking the most dependable criterion for the temperature forecast, Galveston's resulting temperatures have been compared with those at many places in the southern Rockies and southern plains on the morning of the preceding day. When the major temperature decline has occurred in the southern plains and the cold wave threatens the Texas coast, the minimum of the following morning at Galveston is more closely related to the 7 a. m. temperature, of the previous day, at Oklahoma, than any other place. The mean of the 7 a. m. temperatures at Oklahoma and Santa Fe yields somewhat greater accuracy. Galveston's minimum, under these conditions, averaged 17° higher than the mean of these two stations, on the previous morning.

In any situation which gives assurance of fresh to strong northerly winds over the Texas coast, continuing for 24 hours or more, a forecast on this basis is quite accurate, provided the full force of the cold wave has reached the southern plains.

The cold waves of 1886 and 1895 were almost equally severe. The three were of decidedly similar types. In February, 1899, the coldest weather ever experienced in this area was recorded on the 12th and 13th; the fall in temperature was not so large and the wind movement less violent; temperatures were already below normal over much of the country; and the highest temperature on the 11th at Galveston was 48°.

When exceptionally severe and fast-moving, the cold wave on the first morning had not yet reached the southern plains and Rockies and on the second morning had already swept over the Texas coast. In these cases, and there have been only a few, the temperature at Oklahoma is not by any means a reliable index as to the temperature at Galveston the next morning. The fact is clearly shown, on the weather map, by the crowding of the isotherms between Oklahoma and North Platte.

A composite temperature chart for five of these severe and rapidly moving cold waves is marked "A," Figure 10. Here the difference in temperature between Oklahoma and North Platte was 35°. The average difference between these stations, taken from 51 maps, with a cold wave established over the plains region, was 20°.

Figure 11 is a composite temperature chart for five severe cold waves, already established in the southern plains region. The difference in temperature between Oklahoma and North Platte in these cases averaged 19°. Oklahoma's average temperature was 6° and Galveston's average minimum of the next day, 23°.

In the first instances the temperature fell, during the succeeding 24 hours at Oklahoma, 34° while in the second cases the average fall in the next 24 hours was only 9°. Therefore there was, in the first case, a drop of 25° due at Oklahoma in excess of what would have occurred had the cold wave been well established. Using Oklahoma as an index for the minimum temperature forecast in these

cases would have resulted in an average error of 27°, commensurate with the excess fall that took place at that station in the succeeding 24 hours.

Using the night reports, it has long been a precept at the Galveston station that the 7 p. m. temperature at Palestine, Tex., will closely approximate the minimum temperature at Galveston the next morning provided, of course, that the cold wave is in progress and that there are indications that northerly winds will continue through the night. Such a forecast is quite accurate but is not frequently useful.

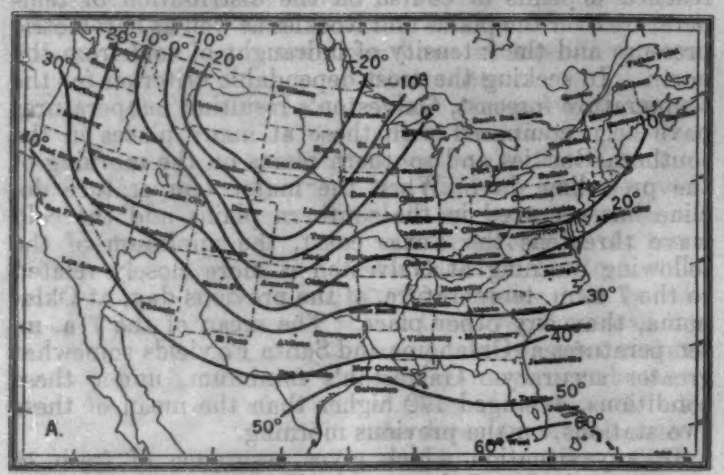

FIG. 10.—Average distribution of temperature 24 hours prior to the five most severe cold waves of record at Galveston. Crowding of isotherms between Oklahoma and North Platte indicates that the full force of the cold wave has not yet reached Oklahoma

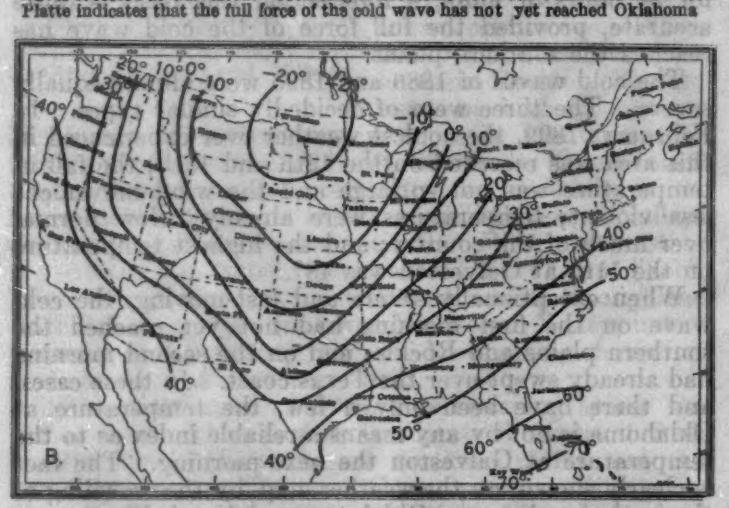

FIG. 11.—Average distribution of temperature approximately 24 hours ahead of five severe cold waves at Galveston, 1892, 1894, 1897, 1911 and 1927. Average minimum at Galveston following day 23°. Cold wave well established over southern plains, indicated by absence of crowding of isotherms between Oklahoma and North Platte apparent in Figure 10

Judged by these standards, the cold wave of January, 1918, was the most violent ever recorded at Galveston. The temperature at Oklahoma on the previous morning was 32°; Galveston's minimum the next day was 16°. The power of the indraught from the north is indicated by the velocity of the wind—56 miles per hour. On the first morning the temperature difference between Oklahoma and North Platte was 38°.

CONCLUSIONS

1. Cold waves with temperatures below 20° occur at Galveston about once in 8 years, at Corpus Christi once in 10 years, at Brownsville once in 15 years; below 25° at Galveston once in 2½ years, at Corpus Christi once in 3 years, at Brownsville once in 3½ years.

2. In cold waves at Galveston a temperature very near the minimum is reached within 30 hours after the initial steep decline begins.

3. When the cold wave arrives before noon, the first day, the minimum occurs generally on the morning of the second day; when it arrives after noon of the first day the minimum is recorded usually the morning of the third day.

4. When clear, the minimum comes shortly after sunrise; when cloudy it is delayed until near noon.

5. Twenty-four hours ahead of the cold wave pressure must be high over Montana and a steep gradient between that locality and the lower Mississippi Valley is essential for a marked fall in temperature. HIGHS with center east of 95° west, and south of 40° north produce little change in temperature.

6. When the LOW is centered in the southern Rockies the time of wind shift on the Texas coast is determined by relative pressures in Utah and southern Louisiana.

Oklahoma seems to be about 24 hours distant in time, judged by the average movement of cold waves.

7. When the HIGH is in the northern plains and pressure is relatively low in the northern Rockies, the depression must be in the west Gulf or lower Mississippi Valley and the cold wave must be in progress on the Texas coast or imminent. Otherwise failure is probable.

8. In any case, a well-defined depression in Utah or Nevada is always indicative of failure.

9. When the cold wave is moving southward and at 7 a. m. is well established in the southern plains and threatens the Texas coast, the mean of the 7 a. m. temperatures at Santa Fe and Oklahoma will be 17° lower than Galveston's minimum of the next morning. When not well established in the southern plains at 7 a. m. the cold wave will not arrive at Galveston in 24 hours unless the pressure gradients are abnormally steep and the impending cold wave exceptionally severe.

10. When exceptionally violent the cold wave may reach the Texas coast from Oklahoma in less than 24 hours, in which case the temperature at Oklahoma is not a reliable index. This condition is characterized by excessive temperature differences between North Platte and Oklahoma.

11. When there is a depression in the southern Rockies and the pressure at Helena, Mont., is 0.60 inch or more above that at New Orleans, a cold wave is threatened. Its violence increases with the gradient.

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AN ANALYSIS OF THE MADISON, WIS., AEROLOGICAL DATA, WITH AN APPLICATION OF THE BJERKNES THEORY

By ARTHUR F. PIPPO

Published investigations of the Bjerknes theory of cyclones in this country are limited mostly to studies of individual storms. It is recognized that a qualitative analysis of the structure of the free atmosphere in cyclones necessarily requires simultaneous observational data from entire areas of pressure disturbances. In this paper an attempt is made to apply the Norwegian theory to the available free-air data obtained at a single station. Applicability of the theory to American weather maps is comprehensively discussed by Rossby and Weightman (1) in the MONTHLY WEATHER REVIEW, December, 1926.

The present work is based on the data secured from a series of 3333 single theodolite observations used in connection with a study of the two daily weather maps covering the period from May, 1919, to February, 1927, inclusive. The observations were made twice daily, 7 a. m. and 3 p. m., ninetieth meridian time, to July 31, 1921, and then daily, at 3 p. m. to the termination of the series. Winds at the observing point (elevation 307 meters above sea level) located on top of a four-story building, are probably little influenced by surrounding objects.

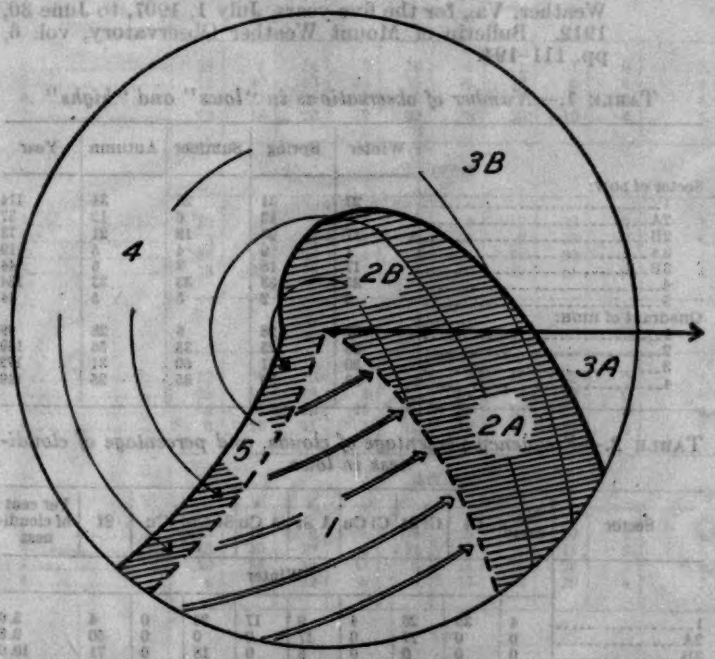

FIG. 1.—Bjerknes idealized cyclone, with numbering of various sectors as used in this study

In the investigation of the free-air winds in cyclones, division into sectors as presented in Figure 1—the Bjerknes idealized cyclone—was used, with numbering of the various sectors for convenience. The characteristics of the different sectors are well known. The broad rain band and the preceding rainless area have been divided into two sections each, one north and the other south of the path of the traveling cyclone. A total of 435 observations for the entire cyclone was obtained, the number of ascensions in the different sectors being given in Table 1.

In attempting to determine the position of an observation in the low, no detailed study of each map was possible, but a discrimination of distinctive weather types appearing on the maps was aided by continued reference to retained weather records. The selections were not limited to well pronounced lows, but included all observations possible of classification. Use of the four seasons was considered advisable.

Figure 2 (*a*, *b*, *c*, *d*, and *e*) has been prepared from the data contained in Tables 5 and 6. Free-air resultant winds in LOWS are represented, by arrows flying with the wind, with length in proportion to movement, in the middle rows of circles drawn for different elevations, and are flanked by circles depicting air movement in HIGHS at the same elevations. No vector was drawn unless three or more observations were included.

In the clear, warm sector (sector 1) southwest winds, veering gradually to west at 4 km. show little variation in direction with the seasons. Here occurs the strongest wind movement below the 2-km. level, velocities being highest in winter and lowest in summer. Taking sectors 2 and 3 into consideration, one would expect a paucity of observations there. Although the majority of the selections made are naturally limited to a low elevation, a surprisingly large number was obtained. The rain area (sector 2) often extends through sector 3 and sometimes into the adjacent HIGH on the northeast, especially in winter. Belief in the probability of the superposed southerly winds overrunning surface easterly winds in these sectors is supported materially by results obtained in a tabulation of cloud direction given in Table 4. With generally light movement throughout, easterly winds at the surface, rapidly turning to south and southwest, are significant. Excepting to some degree in sector 5, in no other region of the LOW does there occur the rapid change in wind direction in the lower layers. Sector 4 is marked by a steady northwest wind in all layers, with the highest velocities above the 2-km. level. Little seasonal change in direction occurs. Remarkably high movement appears here in autumn at 3 km. exceeding movement in any part of either wind system. The narrow rain band or squall sector (sector 5) reveals a backing of north and northwest winds at the surface to southwesterly at 2 to 3 km., where they merge with the southwesterly winds of sector 1. Observations by pilot balloons in sector 5 are necessarily few, but the presence of discontinuities is apparent from the frequency with which surface winds shift suddenly from southwesterly to northwest as the LOW moves east of the station.

A simultaneous tabulation of free-air winds in HIGHS was obtained, totaling 559 observations. These were taken in all HIGHS showing a well-developed wind circulation. The division into quadrants used by Samuels (2) was employed, excepting that the center was omitted, observations appearing in that region and difficult to assign to any quadrant, being discarded. Figure 2a reveals the shallowness of the effect of disturbing influences in HIGHS, the winds obtaining a nearly common mean direction between 2 and 3 kms. appearing at a much higher elevation in summer than in winter. The greatest change in wind direction aloft in HIGHS occurs in the rear half, quadrant 3 presenting the greatest variability. Winds in that quadrant back from ESE. at the surface through NE. to NW. in spring. In autumn and winter they veer from ESE. through SW. to NW., while in summer an unusually rapid shifting

from SE. to NW. results between 2 and 3 kms. The spring condition may possibly be due to the presence of large bodies of cold water to the east at that season. Change of direction aloft in quadrants 1 and 4 are very slight.

The resultant air movement is greatest in quadrants 1 and 4. The velocities in all quadrants increase rapidly, especially in winter, from the surface to about 750 meters. Above that the increase is very gradual in quadrants 1 and 4. Referring to quadrant 3, the negligible movement appearing at 2 kms. is due to slight excess of opposing winds and does not mean little wind. The results of wind direction in HIGHS as presented here substantially agree with those given by Blair (3) except in the rear half above 3 kms. where a northwest instead of southwest movement is obtained, the differences being probably due to dissimilarity of methods of observation. Graphs of the data in Table 6, and not reproduced here, are in good agreement, and somewhat smoother, with those of Samuels (2).

In connection with this study of winds aloft, a tabulation of cloud distribution and movement was made. Tables 2 and 3 contain data on the frequency percentage of clouds and the percentage of cloudiness in LOWS and HIGHS. Table 4 is a summary of mean cloud directions. The same division of LOWS as used for the study of free-air winds is retained here. Cloudless sky occurs most frequently in the first quadrant of HIGHS and is especially marked in winter. In LOWS cloudless sky is rare, occurring occasionally in sectors 1 and 4. The percentage of cloudiness is highest in the third quadrant of HIGHS and in sectors 2, 3, and 5 of LOWS. The percentages in these sectors are actually much higher than given, as invariably overcast skies prevail in cases where observations are not taken, the data for these tables being abstracted entirely from pilot-balloon observations. Cloudiness is least in the first quadrant of HIGHS with an average of 2.3, and in LOWS in sectors 1 and 4, with the least in sector 1 in summer and sector 4 in winter. The most frequent clouds are Ci., St. Cu., and Cu. Ci. is rarely observed within the areas of sliding surfaces in LOWS, occurring usually in sector 1 of LOWS and generally throughout HIGHS, with a maximum frequency in the rear half of the latter. Their direction of movement (see Table 4) is west in LOWS with a veering to WNW. in HIGHS. Distribution of Ci. St. is very much like that of Ci. A. St. from the expected southwesterly direction occurs throughout LOWS except in sector 4. A. Cu. is fairly evenly distributed, although rarely seen in quadrant 1 of HIGHS and in sectors 2B and 4 of LOWS. They are most frequent in summer. St. Cu. is not seen often in sector 1 of LOWS, but the frequency is quite uniform elsewhere in LOWS. They are of the fair-weather type in sector 4, while elsewhere their range is probably between uniform stratus and distinct Cu. Little differences with season appear in direct contrast to Cu. which has the greatest seasonal variation. Cu. is seldom seen in winter highs and probably never in winter LOWS except infrequently in sector 4. They are conspicuous by their presence in summer, however, occurring as frequently as 83 per cent of the time in the first quadrant of highs and 64 per cent in sector 4 of LOWS. St. is fairly limited to sectors 2 and 3 of LOWS, indicating the character of it's formation by forced convection. No tabulation of Nb. is made, observations during their presence being seldom made.

Admitting the limitations placed by the method of using data from a single station, it is believed, however, that the results herein obtained can be accepted quantitatively in strengthening the belief in the presence of the primary sliding surfaces in a large number of cyclones passing this region. Southerly air transport over shallow easterly currents in front of the cyclone center disclosed by the illustrations is supported by cloud movement in the intermediate levels. This sliding surface apparently often extends to the limits of the centripetal currents of the cyclone on the northeast and frequently into the adjacent HIGH, where precipitation often results under favorable conditions. Failure to secure many observations in the narrow rain band in the cold season is indicative of occluded fronts, when storms often develop "washbasin low" characteristics. Advance southward of the polar fronts in the cold months naturally results in the development of occluded fronts. Difficulties appear in defining the fronts in the warm summer months when they have retreated farther north and the typical summer flatness appears.

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TABLE 1.—*Number of observations in "lows" and "highs"*

	Winter	Spring	Summer	Autumn	Year
Sector of LOW:					
1	23	31	26	34	114
2A	6	13	6	12	37
2B	17	23	12	21	73
3A	1	9	4	5	19
3B	17	18	3	6	44
4	35	33	33	33	134
5	2	2	5	5	14
Quadrant of HIGH:					
1	37	28	6	28	99
2	25	25	33	56	139
3	30	51	60	31	172
4	50	39	35	25	149

TABLE 2.—*Frequency percentage of clouds, and percentage of cloudiness in lows*

Sector	No. cloud	Ci	Ci St	Ci Cu	A St	A Cu	St Cu	Cu	St	Per cent of cloudiness
	Winter									
1	4	35	26	4	9	17	26	0	4	5.0
2A	0	0	17	0	17	0	0	0	50	9.8
2B	0	0	0	0	6	0	18	0	71	10.0
3A										
3B	0	0	12	6	35	23	18	0	23	9.2
4	6	20	9	9	9	11	34	6	9	3.9
5	0	0	0	0	0	0	50	0	50	10.0
	Spring									
1	6	26	39	23	6	19	10	19	0	5.3
2A	0	8	15	0	15	15	38	8	23	9.4
2B	0	0	0	0	35	0	43	0	30	9.8
3A	0	44	22	11	22	56	11	44	11	8.0
3B	0	17	17	0	39	6	33	17	11	8.9
4	0	24	12	6	3	9	24	33	9	5.7
5	0	0	0	0	50	0	50	0	0	10.0
	Summer									
1	15	46	23	8	0	15	8	42	0	4.0
2A	0	0	0	0	33	67	67	0	17	9.5
2B	0	0	17	8	8	33	50	33	17	8.6
3A	0	25	50	50	25	0	0	25	0	8.2
3B	0	0	0	0	33	67	33	33	0	8.7
4	3	24	6	6	6	0	21	64	0	5.2
5	0	20	40	20	40	20	20	40	0	8.2

TABLE 2.—*Frequency percentage of clouds, and percentage of cloudiness in lows*—Continued

Sector	No. cloud	C	Cl St	Cl Cu	A St	A Cu	St Cu	Cu	St	Per cent of cloudiness
					Autumn					
1	6	38	21	18	15	21	15	26	3	5.0
2A	0	0	0	0	17	8	33	8	50	9.1
2B	0	0	0	5	29	10	48	0	33	9.8
3A	0	0	20	0	40	20	40	0	40	9.6
3B	0	33	17	0	33	17	33	17	17	9.2
4	0	15	6	0	12	9	57	12	6	6.8
5	0	0	0	0	40	20	60	0	0	9.8
					Year					
1	8	36	27	14	8	18	14	23	2	4.9
2A	0	3	8	0	19	19	35	5	35	9.3
2B	0	0	3	3	22	8	40	5	38	9.7
3A	0	26	26	16	32	32	16	26	16	8.5
3B	0	11	9	2	36	18	27	11	16	9.0
4	3	21	8	5	7	5	34	28	6	5.4
5	0	7	14	0	36	14	43	14	7	9.3

TABLE 3.—*Frequency percentage of clouds and percentage of cloudiness in highs*

Quadrant	No cloud	Ci	CiSt	CiCu	A St	A Cu	StCu	Cu	St	Per cent of cloudiness
					Winter					
1	38	8	14	5	16	5	11	3	0	1.4
2	12	40	12	20	12	16	12	0	4	4.6
3	7	33	20	3	13	27	17	7	13	6.2
4	12	18	20	12	22	18	20	10	4	5.1
					Spring					
1	32	21	7	7	7	4	7	18	0	1.4
2	8	56	24	4	20	24	8	28	0	5.8
3	10	39	29	6	14	16	12	20	2	4.9
4	13	23	18	0	6	10	21	31	0	4.0
					Summer					
1	17	0	0	0	0	0	17	83	0	4.8
2	12	36	18	3	12	24	3	39	0	4.5
3	5	57	13	10	18	20	15	35	0	4.8
4	6	29	11	3	0	17	17	54	6	4.5
					Autumn					
1	25	14	0	4	14	0	25	29	4	4.0
2	18	30	29	5	14	21	14	11	2	3.7
3	10	32	19	13	6	13	10	26	3	5.1
4	4	16	12	0	4	12	32	28	8	5.3
					Year					
1	31	13	7	5	12	3	14	19	1	2.3
2	14	38	22	7	14	22	10	19	1	4.4
3	8	43	20	8	14	19	13	24	3	5.1
4	9	21	16	5	10	15	21	29	4	4.7

TABLE 4.—*Mean direction of clouds in "lows" and "highs"*

	Ci	CiSt	CiCu	A St	A Cu	StCu	Cu	St
Sector of low:								
1	W.	W.	W.	WSW.	WSW.	WSW.	SW.	SW.
2A	W.	W.	------	SW.	SW.	SSW.	S.	SSE.
2B	------	W.	WSW.	WSW.	W.	SE.	SW.	ESE.
3A	WSW.	WSW.	SW.	WSW.	SW	SSE.	SSE	SSW.
3B	W.	WSW.	W.	SW.	SW.	ESE.	N.	E.
4	W.	W.	WNW.	WNW.	WNW.	NW.	NW.	NNW.
5	W.	WNW.	NW.	WSW.	W.	SW.	W.	WNW.
Quadrant of high:								
1	WNW.	WNW.	WNW.	NW.	WNW.	NW.	NW.	W.
2	WNW.	W.	W.	W.	W.	SW.	SSW.	SW.
3	WNW.	W.	W.	W.	WNW.	SSE.	ENE.	S.
4	WNW.	W.	WNW.	NW.	NW.	NNW.	NNW.	NNE.

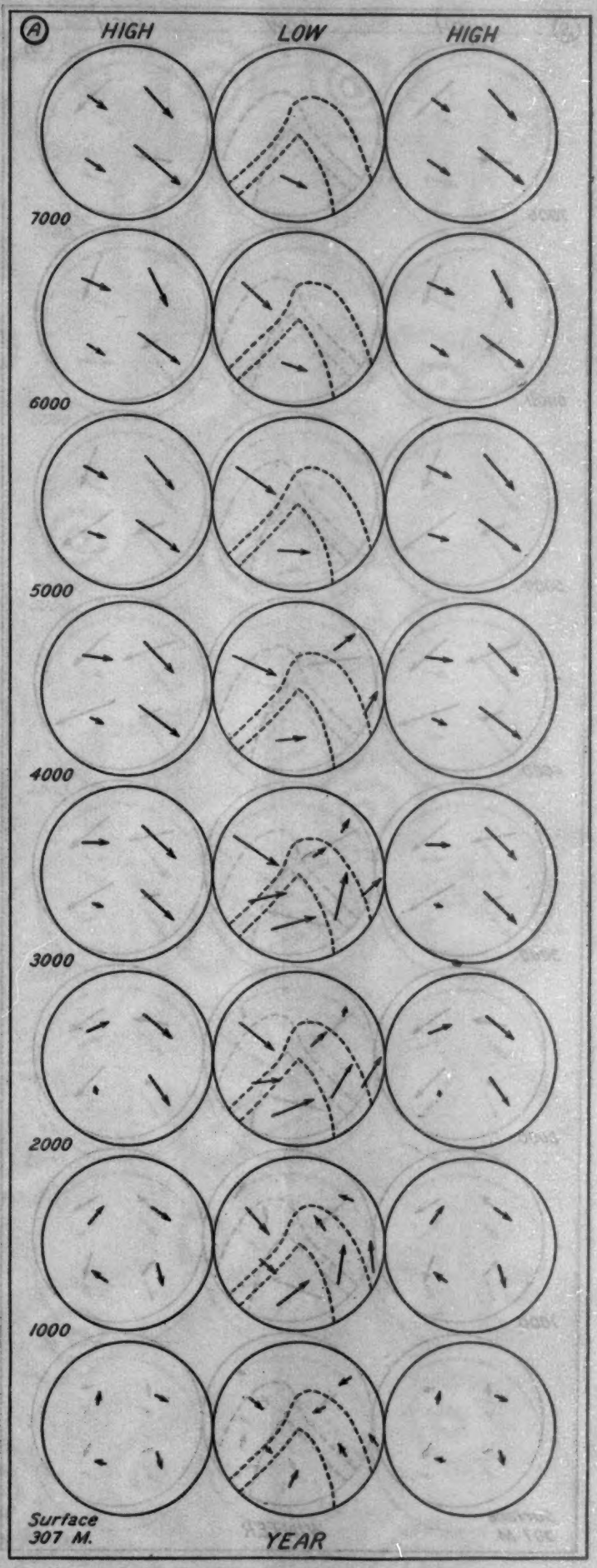
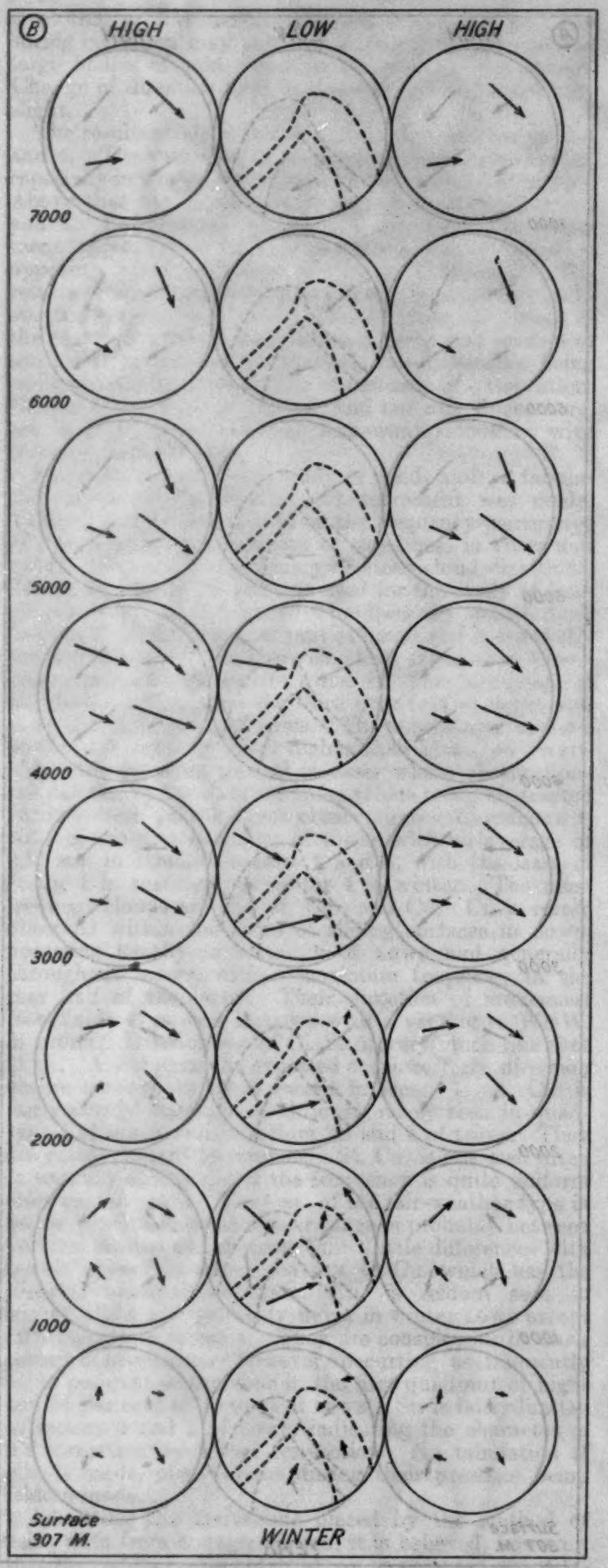


FIG. 2.—Free-air resultant winds in LOWS and HIGHS



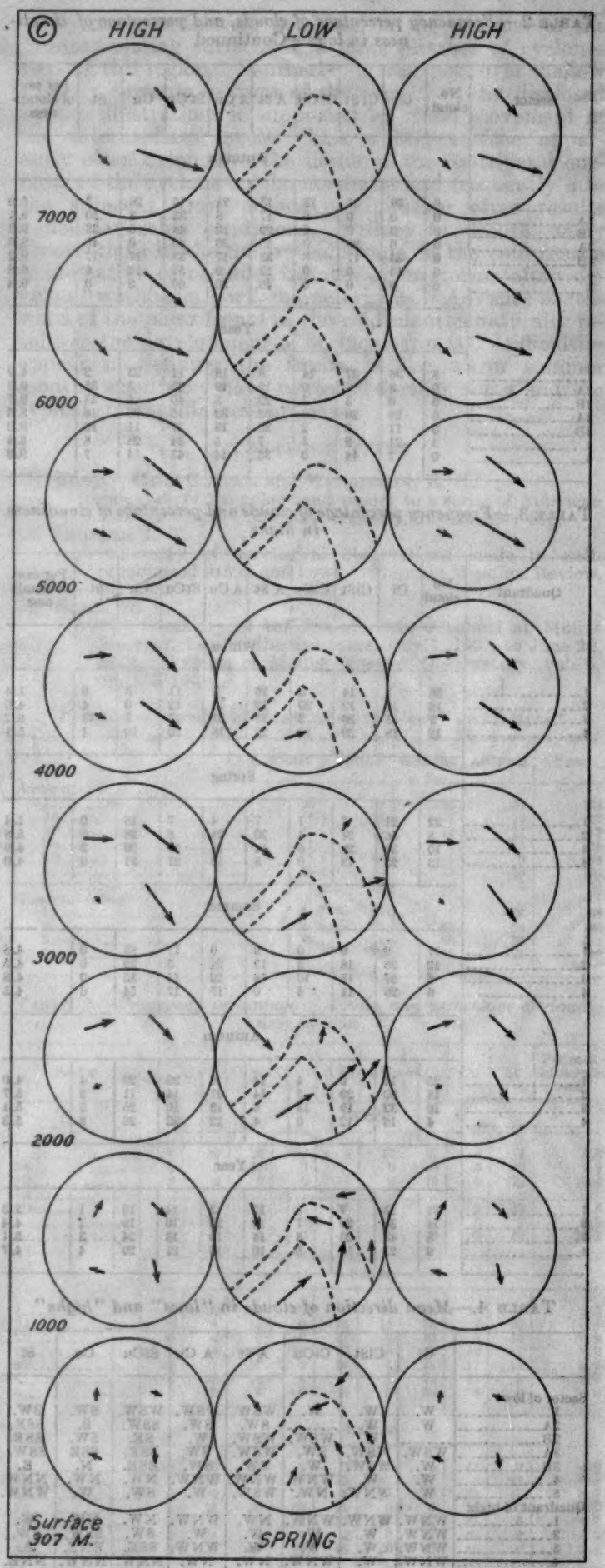


FIG. 2.—Free-air resultant winds in LOWS and HIGHS

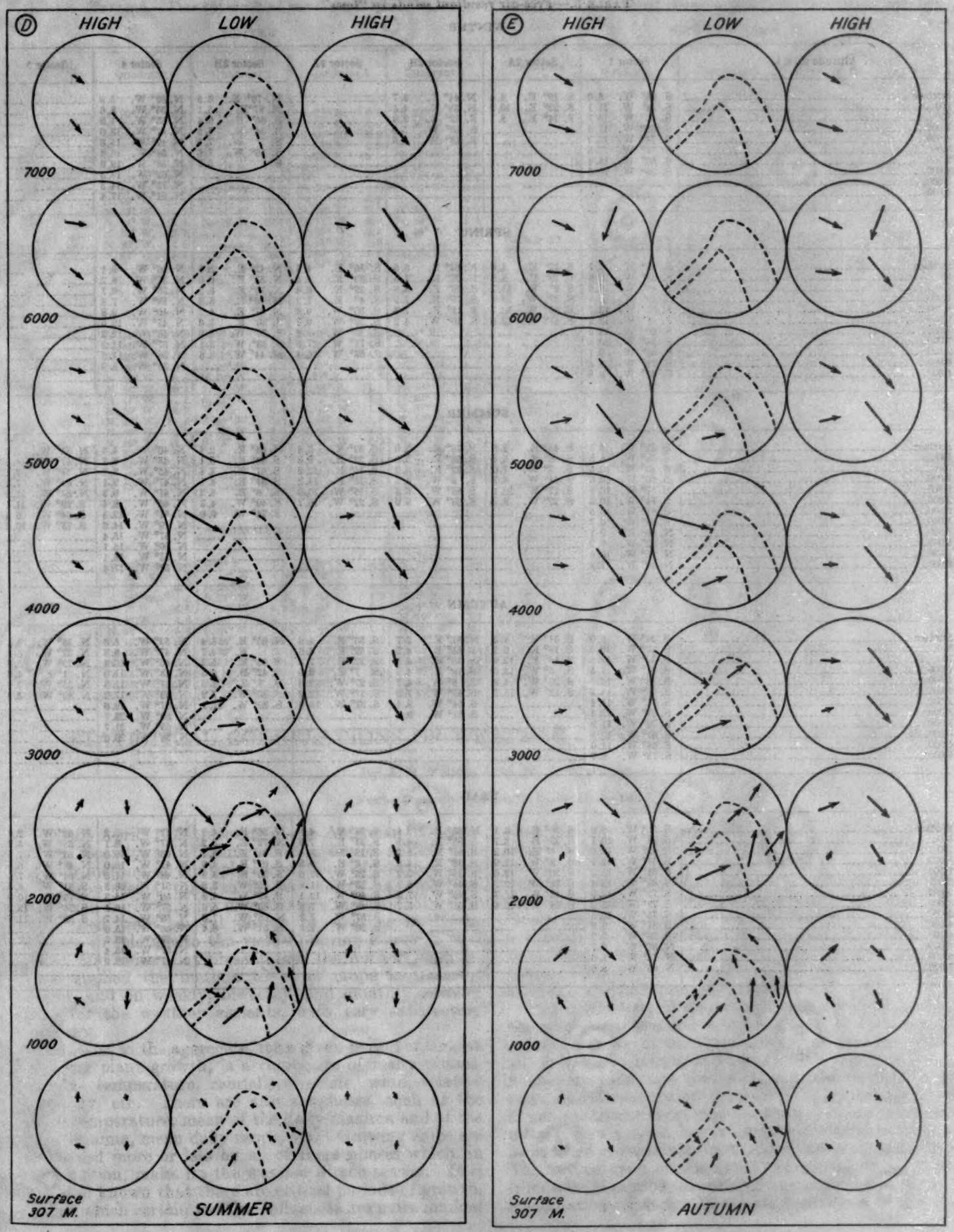


FIG. 2.—Free-air resultant winds in LOWS and HIGHS

TABLE 5.—*Free-air resultant winds in "lows"*

WINTER

Altitude m. s. l.	Sector 1	Sector 2A	Sector 2B	Sector 3A	Sector 3B	Sector 4	Sector 5
Surface	S. 26° W. 6.0	S. 19° E. 4.4	N. 44° E. 3.7	---------- ----	N. 76° E. 3.5	N. 56° W. 5.9	---------- ----
500	S. 34° W. 11.1	S. 22° E. 10.2	N. 63° E. 4.5	---------- ----	N. 87° E. 5.1	N. 55° W. 8.6	---------- ----
750	S. 55° W. 15.7	S. 14° E. 8.1	S. 62° E. 3.9	---------- ----	S. 66° E. 6.4	N. 53° W. 1.2	---------- ----
1,000	S. 63° W. 17.0	---------- ----	S. 10° W. 5.0	---------- ----	S. 34° E. 6.5	N. 47° W. 13.0	---------- ----
1,500	S. 74° W. 16.2	---------- ----	S. 48° W. 6.6	---------- ----	S. 7° W. 7.5	N. 47° W. 15.6	---------- ----
2,000	S. 77° W. 17.5	---------- ----	---------- ----	---------- ----	S. 16° W. 7.6	N. 54° W. 16.6	---------- ----
2,500	S. 80° W. 18.4	---------- ----	---------- ----	---------- ----	S. 5.2	N. 58° W. 19.0	---------- ----
3,000	S. 76° W. 19.5	---------- ----	---------- ----	---------- ----	---------- ----	N. 62° W. 17.3	---------- ----
3,500	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----	N. 71° W. 14.3	---------- ----
4,000	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----	N. 81° W. 17.4	---------- ----

SPRING

Surface	S. 25° W. 6.7	S. 32° E. 4.6	N. 64° E. 5.5	S. 36° E. 4.3	N. 42° E. 5.5	N. 36° W. 5.1	---------- ----
500	S. 23° W. 10.6	S. 19° E. 8.5	N. 77° E. 7.5	S. 32° E. 6.4	N. 53° E. 6.0	N. 39° W. 8.2	---------- ----
750	S. 40° W. 13.5	S. 2° E. 11.7	S. 79° E. 8.8	S. 29° E. 6.8	N. 73° E. 6.3	N. 36° W. 9.7	---------- ----
1,000	S. 49° W. 13.8	S. 9° W. 13.4	S. 75° E. 7.9	S. 4° E. 7.2	N. 76° E. 5.8	N. 18° W. 7.8	---------- ----
1,500	S. 60° W. 12.7	S. 21° W. 13.7	S. 13° E. 7.3	S. 30° W. 9.6	N. 87° E. 4.2	N. 40° W. 9.8	---------- ----
2,000	S. 58° W. 13.2	S. 47° W. 13.6	S. 10° W. 4.2	S. 39° W. 9.7	S. 30° E. 1.6	N. 45° W. 12.0	---------- ----
2,500	S. 60° W. 12.5	---------- ----	---------- ----	S. 38° W. 9.2	S. 70° W. 3.2	N. 56° W. 12.2	---------- ----
3,000	S. 58° W. 10.3	---------- ----	---------- ----	S. 71° W. 7.6	S. 33° W. 3.1	N. 57° W. 11.2	---------- ----
3,500	S. 56° W. 9.1	---------- ----	---------- ----	S. 69° W. 6.4	N. 44° W. 8.6	N. 38° W. 11.6	---------- ----
4,000	S. 70° W. 6.4	---------- ----	---------- ----	---------- ----	---------- ----	N. 33° W. 8.9	---------- ----
4,500	S. 67° W. 5.8	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----

SUMMER

Surface	S. 32° W. 5.3	S. 45° E. 2.5	S. 78° E. 2.0	S. 32° E. 5.4	N. 64° E. 2.4	N. 40° W. 4.6	N. 31° W. 2.5
500	S. 38° W. 8.8	S. 6° E. 5.1	S. 68° E. 3.0	S. 22° E. 9.3	S. 86° E. 5.1	N. 45° W. 6.7	N. 47° W. 4.8
750	S. 43° W. 10.5	S. 7° W. 7.0	S. 32° E. 3.2	S. 16° E. 12.3	S. 67° E. 4.4	N. 45° W. 8.8	N. 51° W. 7.1
1,000	S. 50° W. 10.5	S. 11° W. 8.7	S. 3° W. 4.5	S. 15° E. 14.3	S. 64° E. 4.1	N. 47° W. 9.1	N. 64° W. 7.2
1,500	S. 57° W. 10.6	S. 17° W. 10.1	S. 56° W. 5.8	S. 16° W. 16.0	S. 6° E. 4.2	N. 47° W. 9.3	N. 87° W. 11.0
2,000	S. 74° W. 10.8	S. 20° W. 8.2	S. 63° W. 9.9	S. 22° W. 16.7	S. 40° W. 4.3	N. 46° W. 9.4	S. 79° W. 11.1
2,500	S. 81° W. 10.5	---------- ----	---------- ----	---------- ----	S. 74° W. 6.9	N. 51° W. 12.3	S. 64° W. 9.6
3,000	S. 84° W. 10.7	---------- ----	---------- ----	---------- ----	---------- ----	N. 49° W. 14.6	S. 73° W. 10.6
3,500	N. 86° W. 9.1	---------- ----	---------- ----	---------- ----	---------- ----	N. 57° W. 15.4	---------- ----
4,000	N. 82° W. 9.2	---------- ----	---------- ----	---------- ----	---------- ----	N. 60° W. 16.1	---------- ----
4,500	N. 81° W. 10.9	---------- ----	---------- ----	---------- ----	---------- ----	N. 53° W. 15.1	---------- ----
5,000	N. 69° W. 11.2	---------- ----	---------- ----	---------- ----	---------- ----	N. 57° W. 17.4	---------- ----

AUTUMN

Surface	S. 24° W. 6.0	S. 31° E. 4.3	N. 81° E. 2.7	S. 55° E. 4.8	N. 65° E. 3.4	N. 52° W. 5.6	N. 35° W. 3.3
500	S. 30° W. 10.0	S. 18° E. 9.2	S. 65° E. 4.2	S. 52° E. 6.6	E. 4.7	N. 47° W. 8.8	N. 37° W. 6.1
750	S. 32° W. 11.8	S. 15° E. 12.0	S. 35° E. 4.5	S. 22° E. 7.5	S. 65° E. 5.2	N. 46° W. 10.4	N. 22° W. 5.8
1,000	S. 41° W. 12.5	S. 5° W. 13.6	S. 19° E. 4.9	S. 7° E. 9.5	S. 42° E. 5.3	N. 48° W. 11.0	N. 1° E. 4.6
1,500	S. 56° W. 14.3	S. 20° W. 14.9	S. 8° W. 4.7	S. 27° W. 12.9	S. 8° E. 4.5	N. 57° W. 11.3	N. 33° W. 2.9
2,000	S. 66° W. 14.2	S. 12° W. 15.2	S. 47° W. 7.0	S. 37° W. 12.2	S. 35° W. 7.2	N. 59° W. 17.2	N. 89° W. 5.1
2,500	S. 71° W. 14.4	---------- ----	S. 54° W. 9.4	S. 37° W. 13.9	S. 35° W. 11.1	N. 57° W. 19.0	---------- ----
3,000	S. 69° W. 13.3	---------- ----	S. 51° W. 9.4	---------- ----	---------- ----	N. 59° W. 23.7	---------- ----
3,500	S. 70° W. 11.9	---------- ----	---------- ----	---------- ----	---------- ----	N. 65° W. 21.7	---------- ----
4,000	S. 67° W. 10.5	---------- ----	---------- ----	---------- ----	---------- ----	N. 76° W. 20.6	---------- ----
4,500	S. 65° W. 11.0	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----
5,000	S. 75° W. 9.7	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----

YEAR

Surface	S. 26° W. 6.0	S. 30° E. 4.1	N. 65° E. 3.5	S. 38° E. 4.8	N. 56° E. 4.1	N. 47° W. 5.2	N. 52° W. 2.9
500	S. 34° W. 10.1	S. 23° E. 6.7	S. 86° E. 4.8	S. 31° E. 7.3	N. 72° E. 5.2	N. 47° W. 8.1	N. 58° W. 5.9
750	S. 42° W. 12.6	S. 5° E. 10.2	S. 61° E. 5.2	S. 18° E. 8.4	S. 84° E. 5.7	N. 45° W. 10.0	N. 53° W. 7.6
1,000	S. 51° W. 12.9	S. 8° W. 11.9	S. 38° E. 4.8	S. 6° E. 9.8	S. 67° E. 4.9	N. 41° W. 10.0	N. 48° W. 6.5
1,500	S. 61° W. 13.2	S. 20° W. 12.6	S. 15° W. 5.2	S. 28° W. 11.6	S. 36° E. 3.9	N. 48° W. 11.3	N. 84° W. 7.5
2,000	S. 68° W. 13.4	S. 32° W. 12.2	S. 44° W. 6.3	S. 33° W. 11.8	S. 15° W. 3.8	N. 51° W. 13.3	S. 81° W. 8.3
2,500	S. 72° W. 13.0	S. 18° W. 11.7	S. 49° W. 7.9	S. 40° W. 12.1	S. 49° W. 4.8	N. 56° W. 15.3	S. 75° W. 10.0
3,000	S. 73° W. 13.0	S. 14° W. 15.4	S. 55° W. 5.7	S. 48° W. 7.8	S. 30° W. 5.0	N. 57° W. 16.1	S. 76° W. 12.2
3,500	S. 75° W. 10.6	---------- ----	---------- ----	S. 57° W. 7.3	N. 86° W. 7.0	N. 58° W. 14.7	S. 68° W. 11.7
4,000	S. 81° W. 8.8	---------- ----	---------- ----	S. 30° W. 7.6	S. 51° W. 8.4	N. 66° W. 15.0	---------- ----
4,500	S. 79° W. 9.2	---------- ----	---------- ----	---------- ----	---------- ----	N. 59° W. 13.5	---------- ----
5,000	N. 86° W. 9.7	---------- ----	---------- ----	---------- ----	---------- ----	N. 57° W. 15.4	---------- ----
6,000	N. 72° W. 8.6	---------- ----	---------- ----	---------- ----	---------- ----	N. 47° W. 12.9	---------- ----
7,000	N. 65° W. 9.6	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----	---------- ----

TABLE 6.—*Free-air resultant winds in "highs"*

WINTER

Altitude m. s. l.	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Surface	N. 79° W. 3.8	S. 10° W. 3.9	S. 72° E. 2.5	N. 29° W. 4.7
500	N. 72° W. 5.7	S. 21° W. 6.3	S. 68° E. 3.8	N. 26° W. 6.6
750	N. 66° W. 7.4	S. 34° W. 8.3	S. 56° E. 5.3	N. 14° W. 6.6
1,000	N. 60° W. 8.8	S. 46° W. 9.6	S. 42° E. 6.2	N. 19° W. 8.7
1,500	N. 55° W. 11.7	S. 62° W. 11.0	S. 19° E. 3.5	N. 38° W. 10.6
2,000	N. 55° W. 14.0	S. 78° W. 11.0	S. 35° W. 3.0	N. 44° W. 13.7
2,500	N. 55° W. 16.7	S. 85° W. 12.2	W. 4.1	N. 58° W. 16.4
3,000	N. 51° W. 15.6	N. 79° W. 14.6	N. 79° W. 6.1	N. 60° W. 16.6
3,500	N. 49° W. 15.1	N. 72° W. 16.0	N. 78° W. 6.7	N. 59° W. 18.6
4,000	N. 49° W. 15.2	N. 71° W. 17.3	N. 68° W. 7.5	N. 70° W. 20.6
4,500	N. 44° W. 13.5	N. 68° W. 19.2	N. 77° W. 8.9	N. 59° W. 21.4
5,000	N. 23° W. 12.7	---------- ----	N. 69° W. 9.6	N. 54° W. 20.4
6,000	N. 23° W. 12.5	---------- ----	N. 61° W. 6.0	---------- ----
7,000	N. 47° W. 15.9	---------- ----	S. 80° W. 11.2	---------- ----
8,000	---------- ----	---------- ----	S. 89° W. 8.9	---------- ----

SPRING

Altitude m. s. l.	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Surface	N. 65° W. 3.2	S. 6° W. 3.8	S. 69° E. 3.2	N. 8° W. 4.3
500	N. 61° W. 4.6	S. 14° W. 6.1	S. 71° E. 4.5	N. 9° W. 5.6
750	N. 50° W. 5.3	S. 16° W. 7.0	S. 78° E. 4.7	N. 11° W. 6.2
1,000	N. 49° W. 6.2	S. 26° W. 6.7	S. 73° E. 4.5	N. 13° W. 6.7
1,500	N. 46° W. 8.4	S. 52° W. 7.6	S. 71° E. 3.3	N. 18° W. 8.6
2,000	N. 46° W. 10.2	S. 71° W. 8.4	N. 66° E. 1.5	N. 28° W. 10.6
2,500	N. 47° W. 11.6	S. 81° W. 8.3	N. 2° E. 1.1	N. 33° W. 12.0
3,000	N. 50° W. 13.2	W. 9.4	N. 47° W. 1.8	N. 37° W. 14.4
3,500	N. 49° W. 13.5	S. 86° W. 9.5	N. 30° W. 1.8	N. 56° W. 16.0
4,000	N. 46° W. 12.3	S. 83° W. 9.0	N. 68° W. 3.7	N. 56° W. 14.8
4,500	N. 49° W. 12.8	S. 73° W. 5.8	N. 67° W. 6.2	N. 53° W. 15.6
5,000	N. 52° W. 15.0	W. 7.1	N. 69° W. 5.3	N. 61° W. 18.1
6,000	N. 51° W. 14.8	---------- ----	N. 43° W. 5.8	N. 71° W. 18.0
7,000	N. 43° W. 10.0	---------- ----	N. 50° W. 4.5	N. 72° W. 21.9
8,000	N. 68° W. 12.3	---------- ----	N. 39° W. 11.2	---------- ----
9,000	---------- ----	---------- ----	N. 52° W. 16.9	---------- ----

SUMMER

Altitude m. s. l.	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Surface	N. 25° W. 2.6	S. 2° E. 3.0	S. 77° E. 2.4	N. 7° E. 3.6
500	N. 33° W. 4.7	S. 12° W. 4.9	S. 68° E. 3.8	N. 9° E. 5.1
750	N. 27° W. 5.4	S. 20° W. 5.0	S. 61° E. 4.5	N. 8° E. 5.9
1,000	N. 25° W. 5.3	S. 21° W. 4.9	S. 56° E. 4.0	N. 5° E. 5.9
1,500	N. 7° W. 4.4	S. 28° W. 5.2	S. 51° E. 2.8	N. 8° W. 6.4
2,000	N. 3° W. 4.6	S. 34° W. 4.5	S. 64° E. 0.4	N. 19° W. 7.7
2,500	N. 18° W. 5.8	S. 47° W. 4.3	N. 60° W. 1.4	N. 29° W. 8.1
3,000	N. 12° W. 6.8	S. 56° W. 4.7	N. 46° W. 3.2	N. 32° W. 9.7
3,500	N. 13° W. 7.9	S. 72° W. 5.5	N. 53° W. 3.9	N. 38° W. 11.8
4,000	N. 19° W. 10.4	S. 81° W. 5.4	N. 55° W. 4.3	N. 39° W. 12.9
4,500	N. 23° W. 11.8	N. 89° W. 5.3	N. 57° W. 5.0	N. 50° W. 14.8
5,000	N. 35° W. 12.7	N. 76° W. 5.6	N. 62° W. 5.7	N. 53° W. 14.2
6,000	N. 33° W. 14.2	N. 82° W. 7.3	N. 52° W. 6.7	N. 45° W. 16.6

TABLE 6.—*Free-air resultant winds in "highs"*—Continued

SUMMER—Continued

Altitude m. s. l.	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
7,000	---------- ----	N. 55° W. 5.0	N. 36° W. 7.3	N. 41° W. 16.6
8,000	---------- ----	---------- ----	N. 44° W. 7.9	---------- ----
9,000	---------- ----	---------- ----	N. 58° W. 6.8	---------- ----
10,000	---------- ----	---------- ----	N. 47° W. 6.0	---------- ----
11,000	---------- ----	---------- ----	N. 33° E. 5.0	---------- ----
12,000	---------- ----	---------- ----	N. 8.7	---------- ----

AUTUMN

Altitude m. s. l.	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Surface	N. 51° W. 3.6	S. 19° W. 3.5	S. 55° E. 2.4	N. 23° W. 4.2
500	N. 50° W. 5.6	S. 30° W. 6.1	S. 51° E. 4.5	N. 30° W. 5.1
750	N. 47° W. 6.4	S. 39° W. 7.0	S. 40° E. 5.4	N. 20° W. 5.2
1,000	N. 47° W. 7.1	S. 46° W. 7.5	S. 34° E. 5.4	N. 22° W. 7.8
1,500	N. 42° W. 8.2	S. 56° W. 8.3	S. 13° E. 4.7	N. 25° W. 8.1
2,000	N. 46° W. 10.5	S. 69° W. 8.2	S. 21° W. 2.7	N. 32° W. 9.2
2,500	N. 44° W. 12.6	S. 83° W. 7.5	S. 64° W. 3.6	N. 36° W. 11.2
3,000	N. 38° W. 13.8	N. 86° W. 7.2	S. 74° W. 4.7	N. 41° W. 13.4
3,500	N. 39° W. 15.8	N. 83° W. 8.0	S. 79° W. 5.4	N. 43° W. 14.5
4,000	N. 39° W. 15.4	N. 78° W. 7.7	N. 85° W. 5.6	N. 37° W. 17.6
4,500	N. 36° W. 17.4	N. 73° W. 7.5	W. 7.1	N. 38° W. 17.3
5,000	N. 40° W. 15.8	N. 62° W. 8.6	S. 77° W. 8.7	N. 37° W. 16.7
6,000	N. 21° E. 14.3	N. 65° W. 9.5	N. 86° W. 9.7	N. 33° W. 14.0
7,000	---------- ----	N. 58° W. 7.9	N. 72° W. 10.9	---------- ----
8,000	---------- ----	N. 48° W. 7.6	---------- ----	---------- ----
9,000	---------- ----	N. 60° W. 7.1	---------- ----	---------- ----
10,000	---------- ----	N. 40° W. 2.9	---------- ----	---------- ----

YEAR

Altitude m. s. l.	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Surface	N. 65° W. 3.4	S. 10° W. 3.5	S. 76° E. 2.6	N. 15° W. 4.1
500	N. 61° W. 5.1	S. 22° W. 5.8	S. 69° E. 4.1	N. 14° W. 5.6
750	N. 55° W. 6.2	S. 30° W. 6.7	S. 61° E. 4.7	N. 9° W. 6.1
1,000	N. 53° W. 7.3	S. 39° W. 7.0	S. 54° E. 4.6	N. 13° W. 7.1
1,500	N. 49° W. 9.3	S. 52° W. 7.7	S. 43° E. 3.0	N. 25° W. 8.5
2,000	N. 50° W. 11.3	S. 67° W. 7.6	S. 12° E. 0.6	N. 34° W. 10.6
2,500	N. 49° W. 13.3	S. 79° W. 7.4	N. 77° W. 1.6	N. 44° W. 12.2
3,000	N. 46° W. 13.6	W. 7.8	N. 68° W. 3.0	N. 48° W. 13.7
3,500	N. 45° W. 14.1	W. 8.6	N. 68° W. 3.3	N. 51° W. 15.2
4,000	N. 42° W. 13.7	N. 82° W. 8.4	N. 67° W. 4.7	N. 53° W. 15.8
4,500	N. 40° W. 14.3	N. 76° W. 77.8	N. 71° W. 6.1	N. 51° W. 16.4
5,000	N. 41° W. 14.1	N. 66° W. 8.1	N. 74° W. 6.4	N. 53° W. 16.7
6,000	N. 26° W. 12.8	N. 68° W. 9.2	N. 60° W. 6.7	N. 53° W. 15.4
7,000	N. 42° W. 12.6	N. 57° W. 7.2	N. 58° W. 7.3	N. 51° W. 13.4
8,000	N. 40° W. 11.7	N. 55° W. 7.0	N. 53° W. 8.1	---------- ----
9,000	N. 6° W. 11.2	N. 60° W. 7.1	N. 59° W. 8.4	---------- ----
10,000	---------- ----	N. 40° W. 2.9	N. 72° W. 7.8	---------- ----
11,000	---------- ----	---------- ----	N. 36° W. 3.4	---------- ----
12,000	---------- ----	---------- ----	N. 43° W. 8.0	---------- ----

STATISTICAL CORRELATIONS OF WEATHER INFLUENCE ON CROP YIELDS

By J. B. KINCER and W. A. MATTICE

[Weather Bureau, Washington, D. C., March 14, 1928]

At the April, 1927, meeting of the American Meteorological Society, in Washington, the senior author outlined a method of multiple correlations of weather data with crop yields, that, so far as known, has not been employed heretofore by investigators in this field. The data used were several phases of weather in North Dakota in relation to the yield of spring wheat in that State, and since that presentation the authors, jointly, have applied the method to other crops in different States, and on weekly, biweekly, and monthly units of time for the weather variants, with very satisfactory results.

Weather, in the aggregate, for a given period of time as affecting plant growth, is a composite of many phases, such as temperature, rainfall, sunshine, wind, relative humidity, etc. There are also subphases, such as the mean temperature, mean of the daily maxima and of the daily minima, mean daily range, etc. Growing crops are influenced more or less by all of these phases which, in combination, make up the weather of the season. It is also well known that there are critical periods of growth, during which certain weather influences are more marked than during other times. These critical periods, in some crops at least, are of comparatively short duration and, consequently, it is necessary for best results to use weather variants based on similar short intervals of time, that their greater importance may be reflected in the final result. In most weather and crop correlations the month is used as the basic unit of time, principally by reason of the fact that weather data are usually compiled and published in this way. It is preferable, however, that shorter intervals of time be used in most cases.

The limitations of statistical correlations in studying the influence of weather on crops obtain, to a considerable extent, because of the large number of weather phases, all, or most of which, apparently have more or less influence on yield, and also because of the varying importance of different periods of growth, necessitating the use of comparatively short time intervals. These, combined, usually give a much larger number of variants than can be handled conveniently by the usual correlation methods. The system used in this study segregates, or picks out, from a large number of weather variants, those which, in combination with certain others, contribute to the aug-

mentation of the final multiple coefficient, and discards those which do not make such contribution. By this means a limited number of weather variants is selected, for which it is possible to make a final multiple correlation; and many others, which show an apparent significant relation to yield when correlated separately with it, are discarded. We shall first outline the method as applied to 15 weather variants in North Dakota in relation to the yield of spring wheat in that State, taking the month as the time unit. We shall then apply it to 24 weather variables for the State of Ohio in relation to the yield of corn, on a weekly and biweekly basis.

Table 1 shows the 15 North Dakota weather variants used for the 25 years from 1900 to 1924, inclusive, arranged in order of the magnitude of the correlation coefficients with yield, separately, or as individual weather phases. It will be noted that for these 15 sets of weather data, the highest correlation, −0.66, is for the percentage of possible sunshine in July, and the lowest, +0.47, is for the mean 7 p. m. relative humidity for June. Thus we have 15 different weather phases whose correlations, separately, with spring-wheat yields, range from 0.47 to 0.66, all being apparently significant if the individual correlations with yield are accepted as criteria.

It is not feasible to make a multiple correlation to include all these with the yield. The magnitude of computations is prohibitive, and at the same time the number of variants is so large as to materially vitiate the value of the coefficient obtained. Furthermore, there is excellent a priori reason for believing that some of the weather phases are so closely associated with others that their apparent importance, as shown by separate correlation with yield, is, in reality, much less than is suggested by the magnitude of the coefficient. In many cases these, though showing a substantial correlation with the yield, contribute little or nothing to the final result when included in combination with their associate data.

Our problem, then, is to select from the mass of data only those which, in the final analysis, prove of real value for the purpose of computing or estimating yields. To do this we first select from Table 1 the variant that is apparently most important, as indicated by the magnitude of its coefficient with yield; in this case, the percentage of possible sunshine in July, with a coefficient of −0.66. We then compute the multiple correlation coefficient for this variant and each of the others, successively, with the yield. The results are shown in Table 2 (a), column 3, which indicate that e combined with a gives the highest correlation, 0.80; that is, by combining these variants, and using two values, instead of one, the coefficient is increased from 0.66 to 0.80. We next compute the yield from these two variants by the usual regression equation; the result is shown in Table 3, column a_1.

We designate this new variant a "weather index" (a_1), drop a and e from those under consideration (Table 1), substitute a_1 as a new base, and proceed as before. The results of the second computations are shown in Table 2 (b), column 3, where three sets—Ra_1bx, Ra_1dx, and Ra_1fx—give approximately the same correlation, 0.84. (R represents the multiple coefficient.) However, f does not correlate quite so closely with the remaining weather variants as do b and d; consequently, f is added to a_1 for computation of a third base (or a_2), as before. The resulting data are shown in Table 3 (under a_2), whose straight correlation coefficient with the yield is +0.84, corresponding with the highest multiple correlation in Table 2 (b). With this new base, (a_2), multiple correlations are made with the remaining variables, one at a time, as before, and the highest obtained is through adding d ($R=0.88$) shown in Table 2 (c), column 3. The process is again repeated, the results being shown in division d of this table, column 3, where the final correlation coefficient is 0.89.

Excellent checks as to accuracy of computation are afforded throughout the process. The straight coefficient of correlation between the successive weather indices a_1, a_2, a_3, and a_4 (Table 3) and the yield should agree, approximately, with the highest multiple coefficient in column 3 of the corresponding divisions of Table 2, while the successive means of the weather indices should be substantially the same as the mean of the yield. (See the several means in Table 3.) Again, the final combined multiple coefficient, when all of the selected data are used, in correlation with the yield, should be the same as the straight single coefficient of the final set of weather indices (a_4) with the yield.

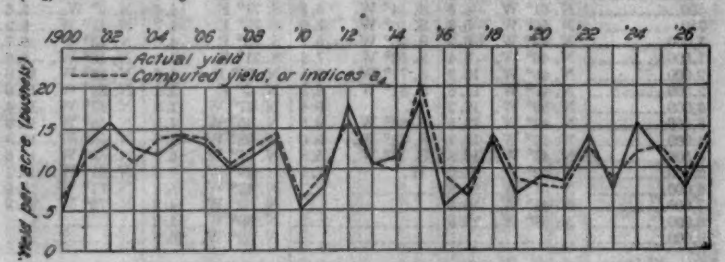


FIG. 1.—Comparison of actual and computed yields of spring wheat in North Dakota

Figure 1 affords a graphic comparison of computed yields from the selected five sets of weather data for the 25-year period 1900–1924 with the actual yield. It will be noted that there are included in this graph the years 1925, 1926, and 1927. This projection was made by applying the several constants obtained for the 1900–1924 data to the same weather phases for the succeeding three years, and was intended to test the results through application to years not included in the original equation. The constants established by the regression equation apply very nicely to these succeeding three years.

The Wallace-Snedecor[1] method of multiple correlations was used in these computations. By this method the multiple coefficient for a and e (Table 2 (a), column 3) is found by solving the following equation:

$$R^2=\beta xa.\ rax.+\beta xe.\ rex. \qquad (1)$$

and the weather indices (a_1, Table 3) from the following:

$$X=Mx+\beta xa\frac{\sigma x}{\sigma a}(A-M_A)+\beta xe\frac{\sigma x}{\sigma e}(E-M_E) \qquad (2)$$

where A and E, respectively, are the weather data for the several years, M_A and M_E, the means for these, and Mx, the mean of the yields. The betas are found by solving the simultaneous equation,

$$\begin{aligned} \beta xa+rae.\ \beta xe&=rax \\ rae.\ \beta xa+\ \beta xe&=rex \end{aligned} \qquad (3)$$

While the final weather indices a_4 (Table 3) represent for the several years the computed yields for the five weather variants selected, to project the curve into the future, or for the purpose of applying the constants to

[1] Wallace, H. A., and Snedecor, George W. 1925. Correlation and machine calculation. Official publication, Iowa State College, 23: No. 35.

future years, it is more convenient to make a single multiple correlation of these five variants, and establish constants for each in the usual way by means of a regression equation. This may be done by enlarging the equations to include all five weather variants, instead of two, as here given. By doing this the multiple coefficient is 0.89, and the regression constants are found to be as follows: $-0.270A, +0.788E, -0.414F, -0.473D, +0.090M, +77.5$. The several weather data, used are (a) percentage of possible sunshine in July; (e) rainfall, April to June; (f) mean temperature, June; (d) mean temperature, July, and (m) percentage of possible sunshine, June. In Table 1, the rainfall data, mean temperature, and the number of cloudy days, represent State averages as computed from all Weather Bureau stations, and the other data as computed from first-order stations only, represented by Williston, Bismarck, and Devils Lake, N. Dak., and Moorhead, Minn.

It happens occasionally that weather conditions may not be directly responsible for partial crop failures, and in such case it appears preferable, in correlation work, not to include such years, when the facts are known, in computing coefficients and regression equations. For example, in the series of years covered by this study of spring wheat yields in North Dakota, 1916 stands out as a case in point. In that year the weather was favorable and prospects for a fairly good crop bright until near harvest time, when, within a few days, black rust played havoc with the yield. If we omit 1916, and make our correlation include the other 24 years, some changes are shown in the weather data selected as the most important, but at the same time, the final coefficient is increased from 0.89 to0.93.

WEATHER AND CORN YIELDS IN OHIO

Reference has been made to the desirability of studying the effect of weather on crop yields with the basic weather variants compiled on unit periods of time shorter than the month. To apply the system used in the case of North Dakota and spring wheat to weather records and corn yields in Ohio, data, including the several weather phases, for the latter State were compiled on a weekly and biweekly basis, and straight correlations made with yield for numerous periods and many different weather phases. In this case a large number showed apparently significant correlations, as indicated in Table 4, where 24 separate coefficients, ranging from 0.40 to 0.66, are shown for the period from 1900 to 1925.

Table 5 for Ohio is similar to Table 3 for North Dakota, and the previously given explanation of the latter applies to this also. It will be noted that the selection of a, c, l, n, q, and o (from Table 4), raises the base coefficient successively from 0.66 to 0.84, 0.89, 0.91, 0.92, and 0.93. No other combination gives an increase above 0.93, and we therefore conclude that this is the maximum value that can be obtained from the data in hand. However, a coefficient of 0.93, for so long a period, with no year or data of any kind omitted, is very satisfactory. The basic data of rainfall for Ohio were compiled from State averages of records for all stations, and the other values from records of the first-order stations at Cincinnati, Columbus, and Cleveland, well distributed across the State. Figure 2 affords a graphic comparison of the computed yields of corn with the actual yields for the 25-year period.

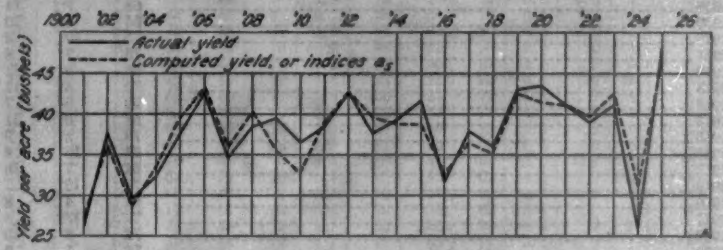


FIG. 2.—Comparison of actual and computed yields of corn in Ohio

THE IMPORTANCE OF HIGH CORRELATIONS

In the correlation of weather data with crop yields the importance of a high coefficient, and a comparatively small increase in one already relatively high which may be obtained by adding additional data, are not always appreciated. The relative value of a correlation for estimating purposes increases much more rapidly than the increase in the coefficient itself. In the absence of information as to the condition of a growing crop, or of factors influencing its development, the average yield is the best indicator as to what the harvest is likely to be, and the standard deviation of yields from this average for a series of years affords a measure of the accuracy of predictions by this method. However, a computation or estimate based on something other and better than the mean will show a standard deviation from the actual yields smaller than the standard deviations of yields.

The relative value of correlations represented by coefficients of different magnitudes may be determined in this way: that is, by comparing the standard deviation of the residuals of actual yields from computed yields, with the standard deviation of yields, when the regression equations are based on sets of data having various degrees of correlation, such as the several weather indices shown in Tables 3 and 5. Yield estimates from data having a correlation coefficient of 0.40 reduces the standard deviation less than 10 per cent; 0.50, about 13 per cent; 0.60, about 20 per cent; 0.70, 29 per cent; 0.80, 40 per cent; 0.90, 56 per cent; 0.95, 69 per cent; and 0.98, 80 per cent. Thus the raising of the coefficient in the case of corn in Ohio four points, from 0.89 to 0.93, by adding the last three weather phases, has as much value as raising the base a coefficient nine points from 0.66 to 0.75. It is also equivalent to an increase of 16 points in raising a coefficient from 0.40 to 0.56.

TABLE 1.—*North Dakota*

Year	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
1900	74	9	5	68	3	67	20	74	40	26	27	5	68	42	42
1901	65	7	6	71	7	62	28	79	43	20	22	6	51	63	63
1902	70	3	12	68	8	58	22	56	62	22	25	4	56	50	61
1903	71	3	9	67	6	62	25	58	50	23	24	6	61	50	46
1904	73	3	8	64	9	61	23	56	53	21	26	6	56	47	57
1905	66	1	11	66	8	60	24	47	54	20	22	5	46	61	64
1906	70	3	14	67	10	62	22	40	62	20	24	10	54	64	65
1907	68	1	9	66	4	62	25	50	52	23	24	4	56	60	58
1908	68	7	11	69	8	60	23	53	55	20	28	3	64	48	60
1909	65	4	10	67	8	63	24	57	53	21	22	7	64	64	62
1910	75	19	8	70	4	67	27	62	46	27	29	4	72	46	42
1911	76	7	8	65	7	67	26	64	52	24	27	3	61	44	58
1912	66	6	11	66	9	62	22	46	56	24	23	6	68	62	54
1913	70	5	11	66	5	66	24	51	52	25	25	6	70	53	51
1914	79	8	7	72	10	62	26	70	50	21	24	3	69	54	64
1915	58	0	11	62	9	57	22	48	52	22	21	8	51	58	59
1916	76	5	9	73	8	58	24	53	47	21	22	3	58	60	58
1917	77	13	4	71	4	60	29	74	32	26	28	3	66	44	44
1918	64	7	10	66	6	63	25	54	50	24	25	7	70	52	51
1919	73	12	7	71	7	67	24	70	48	23	26	3	72	45	56
1920	81	4	8	68	6	62	25	64	44	22	24	2	70	50	55
1921	77	13	8	71	8	68	23	60	48	22	24	4	67	50	57
1922	72	5	10	66	8	64	20	57	50	22	24	4	67	52	56
1923	74	7	6	71	7	66	25	72	43	23	24	4	71	56	52
1924	75	1	9	66	8	59	24	54	44	22	23	4	53	51	55
Means	71	6	9	68	7	63	24	59	50	23	25	5	62	53	56
σ	5.31	4.38	2.27	2.71	1.88	3.15	2.22	10.02	6.82	2.00	2.12	1.87	7.74	6.76	6.42
rx's	−.66	−.64	+.62	−.60	+.57	−.57	−.57	−.55	+.55	−.54	−.54	+.52	−.48	+.48	+.47

a, Percentage of possible sunshine, July.
b, Number of days with maximum temperature above 90°, June 1 to July 31.
c, Number of cloudy days, May.
d, Mean temperature, July.
e, Total rainfall, April to June, inclusive.
f, Mean temperature, June.
g, Mean daily temperature range, May.
h, Percentage of possible sunshine, May.
i, Mean 7 p. m. relative humidity, May.
j, Mean daily temperature range, June.
k, Mean daily temperature range, July.
l, Number of cloudy days, July.
m, Percentage of possible sunshine, June.
n, Mean 7 p. m. relative humidity, July.
o, Mean 7 p. m. relative humidity, June.
rx's, Coefficients of correlation with yield of spring wheat.

TABLE 2

(a) 1	(a) 2	(a) 3	(b) 1	(b) 2	(b) 3
rax −0.66	rab +0.43	Rabx 0.77	ra₁x +0.81	ra₁b −0.54	Ra₁bx 0.84
rbx − .64	rac − .51	Racx .74	rbx − .64	ra₁c + .66	Ra₁cx .82
rcx + .62	rad + .53	Radx .73	rcx + .62	ra₁d − .54	Ra₁dx .84
rdx − .60	rae − .18	Raex .89	rdx − .60	ra₁f − .46	Ra₁fx .84
rex + .57	raf + .32	Rafx .76	rfx − .57	ra₁g − .60	Ra₁gx .82
rfx − .57	rag + .32	Ragx .76	rgx − .57	ra₁h − .57	Ra₁hx .82
rgx − .57	rah + .48	Rahx .71	rhx − .55	ra₁i + .64	Ra₁ix .81
rhx − .55	rai − .42	Raix .72	rix + .55	ra₁j − .60	Ra₁jx .81
rix + .55	raj + .20	Rajx .76	rjx − .54	ra₁k − .58	Ra₁kx .82
rjx − .54	rak + .39	Rakx .73	rkx − .54	ra₁l + .64	Ra₁lx .81
rkx − .54	ral − .67	Ralx .67	rix + .52	ra₁m − .54	Ra₁mx .81
rix + .52	ram + .45	Ramx .69	rmx − .48	ra₁n + .63	Ra₁nx .81
rmx − .48	ran − .52	Ranx .68	rnx + .48	ra₁o + .65	Ra₁ox .81
rnx + .48	rao − .28	Raox .73	rox + .47		
rox + .47					

(c) 1	(c) 2	(c) 3	(d) 1	(d) 2	(d) 3
ra₂x +0.84	ra₂b −0.63	Ra₂bx 0.85	ra₃x +0.88	ra₃b −0.71	Ra₃bx 0.88
rbx − .64	ra₂c + .65	Ra₂cx .84	rbx − .64	ra₃c + .60	Ra₃cx .88
rcx + .62	ra₂d − .43	Ra₂dx .88	rcx + .62	ra₃g − .60	Ra₃gx .88
rdx − .60	ra₂g − .58	Ra₂gx .85	rgx − .57	ra₃h − .69	Ra₃hx .88
rgx − .57	ra₂h − .00	Ra₂hx .84	rhx − .55	ra₃i + .62	Ra₃ix .86
rhx − .55	ra₂i + .59	Ra₂ix .84	rix + .55	ra₃j − .51	Ra₃jx .89
rix + .55	ra₂j − .63	Ra₂jx .84	rjx − .54	ra₃k − .54	Ra₃kx .88
rjx − .54	ra₂k − .58	Ra₂kx .84	rkx − .54	ra₃l + .63	Ra₃lx .88
rkx − .54	ra₂l + .57	Ra₂lx .84	rix + .52	ra₃m − .65	Ra₃mx .89
rix + .52	ra₂m − .73	Ra₂mx .86	rmx − .48	ra₃n + .54	Ra₃nx .88
rmx − .48	ra₂n + .63	Ra₂nx .84	rnx + .48	ra₃o + .56	Ra₃ox .88
rnx + .48	ra₂o + .67	Ra₂ox .85	rox + .47		
rox + .47					

Column 1: Correlation coefficients of the several series of weather data (Table 1) with yield of spring wheat.
Column 2. Coefficients of intercorrelations of weather data in Table 1.
Column 3. Multiple coefficients of base weather data, or indices, and those remaining, as indicated by designations *a*, *b*, *c*, etc., in Table 1.

TABLE 3

	x	a_1	a_2	a_3	a_4	v
1900	4.9	6.2	5.8	6.5	6.3	+1.4
1901	13.1	13.6	13.7	12.1	11.2	−1.9
1902	15.9	12.5	13.9	13.5	13.2	−2.7
1903	12.7	10.2	10.7	11.1	10.9	−1.8
1904	11.8	12.2	12.8	14.1	13.8	+2.0
1905	14.0	14.2	14.8	15.0	14.1	+0.1
1906	13.0	14.3	14.3	14.2	13.9	+0.9
1907	10.0	9.6	10.2	11.1	10.5	+0.5
1908	11.6	13.4	14.1	13.2	12.7	+1.1
1909	13.7	14.6	14.2	14.1	14.4	+0.7
1910	5.0	6.7	6.2	6.1	6.1	+1.1
1911	8.0	9.1	8.3	9.9	9.6	+1.6
1912	18.0	15.1	15.0	15.2	16.0	−2.0
1913	10.5	9.7	9.1	10.2	10.6	+0.1
1914	11.2	10.7	11.1	9.5	9.7	−1.5
1915	18.2	18.3	19.2	20.4	20.5	+2.3
1916	5.5	10.1	11.8	9.7	9.1	+3.6
1917	8.0	5.9	7.6	6.9	6.6	−1.4
1918	13.6	13.1	12.9	13.4	14.2	+0.6
1919	6.9	10.3	9.3	8.3	8.6	+1.7
1920	9.0	6.2	7.3	7.8	7.9	−1.1
1921	8.5	9.7	8.5	7.6	7.5	−1.0
1922	14.1	11.7	11.4	12.1	12.5	−1.6
1923	7.4	9.9	9.3	8.3	8.6	+1.2
1924	15.7	10.5	11.9	12.6	12.0	−3.7
Mean	11.2	11.1	11.3	11.3	11.2	------
σ's	3.76	3.02	3.15	3.31	3.34	1.75
rx's	------	+.81	+.84	+.88	+.89	------

x, Yield of spring wheat, bushels per acre, North Dakota.
a_1, Weather indices computed from a_1 and e (Table 1), by multiple correlation. (See also Table 2 (a), column 3).
a_2, Weather indices computed from a and f (including a, e, and f, Table 1), by multiple correlation. (See also Table 2 (b), column 3).
a_3, Weather indices computed from a_2 and d, (including a, e, f, and d, Table 1), by multiple correlation. (See also Table 2 (c), column 3).
a_4, Weather indices (or final computation of yields) from a_3 and m (including a, e, f, d, and m, Table 1), by multiple correlation. (See also Table 2 (d), column 3).
v, Variations of a_4 (final computation of yields) from x (actual yield).
rx's, Coefficient of correlation of successive weather indices with yield of spring wheat (x).

TABLE 4.—*Ohio*

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	w	y	z
1901	49	74	45	0.1	63	82	27	73	63	56	67	0.1	67	64	93	83	0.6	62	60	82	0.6	1.9	0.7	1.3
1902	64	53	54	0.8	72	79	47	78	60	62	76	0.8	69	68	85	75	1.0	55	71	84	1.8	1.1	2.6	0.8
1903	49	71	41	0.3	72	86	47	76	49	65	72	0.6	50	69	84	75	1.6	70	57	68	1.2	2.8	1.8	0.3
1904	53	70	45	0.4	72	81	51	78	54	63	72	0.7	63	70	78	60	0.3	66	59	76	0.3	2.3	1.0	0.8
1905	66	66	66	1.4	73	82	51	76	75	64	81	1.0	62	68	78	70	1.3	66	64	79	0.7	2.2	1.7	3.2
1906	76	61	61	2.0	70	88	64	85	68	62	81	0.6	76	76	77	70	1.0	57	64	74	1.6	1.8	2.2	3.0
1907	64	64	38	0.5	63	78	43	67	66	56	81	1.6	38	60	82	74	0.9	65	61	74	1.7	2.4	3.3	1.0
1908	61	62	81	1.3	70	77	55	80	56	60	74	0.8	75	71	84	75	0.2	58	71	74	1.3	1.1	2.1	2.2
1909	58	63	59	0.3	76	81	48	76	74	68	78	0.9	47	69	80	71	1.5	72	57	77	0.8	2.9	1.7	2.6
1910	58	64	51	0.3	64	84	55	66	51	55	74	0.9	43	58	86	77	0.7	68	53	73	0.4	1.4	1.3	0.5
1911	57	58	75	0.3	83	77	41	81	63	73	76	1.0	61	72	78	67	1.0	65	60	80	0.6	2.0	1.6	1.7
1912	74	68	62	1.5	76	82	58	72	77	67	74	1.2	89	63	82	73	0	46	62	80	2.0	1.0	3.2	1.9
1913	59	70	62	0.8	73	81	54	73	62	65	67	2.1	83	63	84	74	0.3	61	66	82	1.0	1.6	3.1	1.2
1914	61	52	75	1.3	82	84	33	85	48	72	84	1.0	78	75	89	79	1.0	58	73	80	0.4	1.4	1.4	1.7
1915	74	75	31	0.9	66	73	48	74	72	59	76	1.6	72	65	80	71	1.6	65	81	77	2.8	3.2	4.4	1.9
1916	69	73	53	1.2	74	87	42	70	60	66	69	0.2	56	62	91	80	2.1	68	52	74	1.1	3.5	1.3	1.6
1917	66	74	46	0.4	71	80	35	75	61	63	72	1.3	53	67	86	77	1.5	67	59	71	1.0	4.6	2.3	1.0
1918	60	69	64	0.7	85	86	56	77	66	76	59	0.5	68	69	87	78	0.9	51	60	70	0.4	1.6	0.9	1.1
1919	61	54	96	1.6	84	82	59	82	65	73	78	1.2	77	74	87	78	0.6	69	59	87	2.0	0.6	3.2	2.6
1920	71	59	67	1.3	78	76	38	72	79	68	78	1.0	60	63	70	70	0.7	57	57	87	1.0	1.0	2.0	2.5
9121	65	72	84	0.8	82	79	94	74	70	72	79	1.2	69	65	89	78	0.3	70	72	82	0.7	1.0	1.9	2.1
1922	58	61	76	0.9	75	81	58	81	52	66	72	1.2	59	72	84	75	0.6	63	55	82	0.8	1.1	2.0	1.0
1923	66	51	89	0.6	81	75	54	81	66	71	72	0.8	74	72	80	71	1.1	68	64	75	0.4	1.2	1.2	1.4
1924	59	73	45	0.5	65	85	52	71	56	57	72	0.8	55	62	84	74	2.2	71	62	77	0.2	3.0	1.0	0.8
1925	70	44	88	1.1	79	69	91	90	64	68	79	1.3	77	80	78	70	0.5	52	75	83	1.2	0.5	2.5	2.9
Means	63	64	62	0.9	74	81	52	77	63	65	75	1.0	65	68	83	74	0.9	63	63	78	1.0	1.9	2.0	1.6
σ's	7.07	8.32	17.16	0.49	6.57	4.44	14.76	5.64	8.55	5.73	5.40	0.43	12.54	5.30	4.36	3.89	0.55	6.77	7.11	4.71	0.63	0.98	0.88	0.77
rx's	+.66	−.61	+.61	+.57	+.53	−.53	+.50	+.50	+.49	+.48	+.48	+.48	+.47	+.46	−.45	−.42	−.42	−.41	+.40	+.40	+.40	−.50	+.52	+.68

a, P. m. relative humidity for the week ending Aug. 11.
b, P. m. relative humidity for the week ending June 2.
c, Percentage of possible sunshine for the week ending June 2.
d, Total precipitation for the week ending Aug. 11.
e, Maximum temperatures for the week ending June 2.
f, Maximum temperatures for the week ending Aug. 25.
g, Percentage of possible sunshine for the week ending Apr. 7.
h, Maximum temperatures for the week ending June 9.
i, P. m. relative humidity for the week ending Aug. 18.
j, Mean temperatures for the week ending June 2.
k, Maximum temperatures for the week ending Sept. 22.
l, Total precipitation for the week ending July 14.
m, Percentage of possible sunshine for the week ending June 9.
n, Mean temperatures for the week ending June 9.
o, Maximum temperatures for the week ending July 28.
p, Mean temperatures for the week ending July 28.
q, Total precipitation for the week ending June 9.
r, P. m. relative humidity for the week ending June 9.
s, Maximum temperatures for the week ending Apr. 28.
t, Maximum temperatures for the week ending June 16.
u, Total precipitation for the week ending July 21.
w, Total precipitation for the two weeks June 2–16.
y, Total precipitation for the two weeks July 14–28.
z, Total precipitation for the two weeks Aug. 11–25.

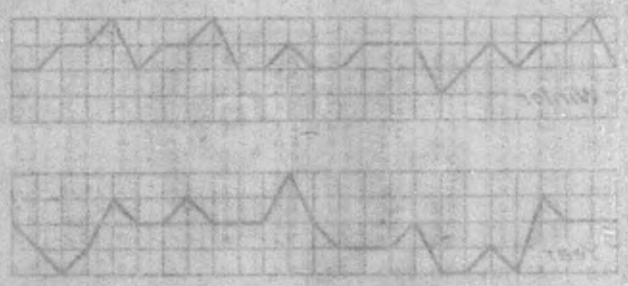
TABLE 5

	X	a_1	a_2	a_3	a_4	a_5	V
1901	26.1	28.9	26.6	26.5	27.7	26.5	+0.4
1902	38.0	36.9	36.4	36.5	36.5	36.2	−1.8
1903	29.6	28.3	27.8	28.6	28.2	28.6	−1.0
1904	32.5	30.6	30.3	31.1	32.5	33.7	+1.2
1905	37.8	39.7	39.6	39.5	38.9	39.7	+1.9
1906	42.6	43.3	41.5	42.8	42.4	43.2	+0.6
1907	34.6	34.4	36.9	35.4	35.6	35.9	+1.3
1908	38.5	39.9	39.1	39.6	40.6	40.2	+1.7
1909	30.5	35.0	35.0	35.4	34.7	35.4	+4.1
1910	36.5	33.8	33.9	32.2	32.9	32.6	−3.9
1911	38.6	37.2	37.3	38.1	38.0	38.9	+0.3
1912	42.8	42.6	43.0	41.7	42.9	42.8	0
1913	37.5	36.0	40.1	39.0	39.9	39.6	+2.1
1914	39.1	38.9	38.9	40.2	40.0	38.8	−0.3
1915	41.5	37.7	39.9	39.2	38.2	38.7	−2.8
1916	31.5	39.0	36.2	35.2	33.6	32.4	+0.9
1917	38.0	36.5	37.8	37.6	36.8	36.3	−1.7
1918	36.0	36.7	35.1	35.4	35.6	35.0	−1.0
1919	43.0	42.3	42.7	43.5	43.7	42.6	−0.4
1920	43.4	42.0	41.7	40.5	40.7	41.2	−2.2
1921	41.0	42.1	42.5	41.6	42.4	41.0	0
1922	39.0	37.8	38.6	39.3	39.8	39.5	+0.5

TABLE 5—Continued

	X	a_1	a_2	a_3	a_4	a_5	V
1923	41.0	43.3	42.2	42.7	42.2	42.5	+1.5
1924	26.0	33.3	33.1	32.2	30.7	30.9	+4.9
1925	48.0	45.0	45.5	47.3	47.4	47.7	−0.3
Means	37.7	37.6	37.7	37.6	37.7	37.6	
σ's	5.21	4.41	4.63	4.78	4.82	4.86	1.95
rx's		.84	.89	.91	.92	.93	

X, Yield of corn, bushels per acre, Ohio.
a_1, Weather indices computed from a and c (Table 4) by multiple correlation.
a_2, Weather indices computed from a_1 and l (including a, c, and l, Table 4), by multiple correlation.
a_3, Weather indices computed from a_2 and n (including a, c, l, and n, Table 4), by multiple correlation.
a_4, Weather indices computed from a_3 and q (including a, c, l, n, and q, Table 4), by multiple correlation.
a_5, Weather indices (or final computation of yields) from a_4 and o (including a, c, l, n, q, and o, Table 4), by multiple correlation.
V, Variations of a_5 (final computation of yields) from x (actual yield).
rx's, Coefficient of correlation of successive weather indices with yield of corn (x).



HOURLY PRECIPITATION AT MEMPHIS, TENN.

By A. R. LONG

[Weather Bureau, Memphis, Tenn., December, 1927]

The data used in this paper were taken from the station records at Memphis, Tenn., for the 20-year period, 1907–1926, inclusive. The plan is similar to the ones used by Feldwisch, Ray, and others. The tables and graphs are based on 0.01 inch or more of precipitation per hour. The means and averages were compiled for all months of the year in order to make comparisons by seasons.

The hourly amounts were interpolated for the short periods when the automatic recorder was out of order and for the extreme months when the tipping bucket was removed to prevent damage from freezing. It is believed that the hourly amounts in winter represent the true hourly amounts to a high degree of accuracy, as 75 per cent or more of the winter precipitation is recorded by the tipping bucket. The amount of snowfall at Memphis is small and considerably less than at the more northerly stations. The personal equation should be negligible as

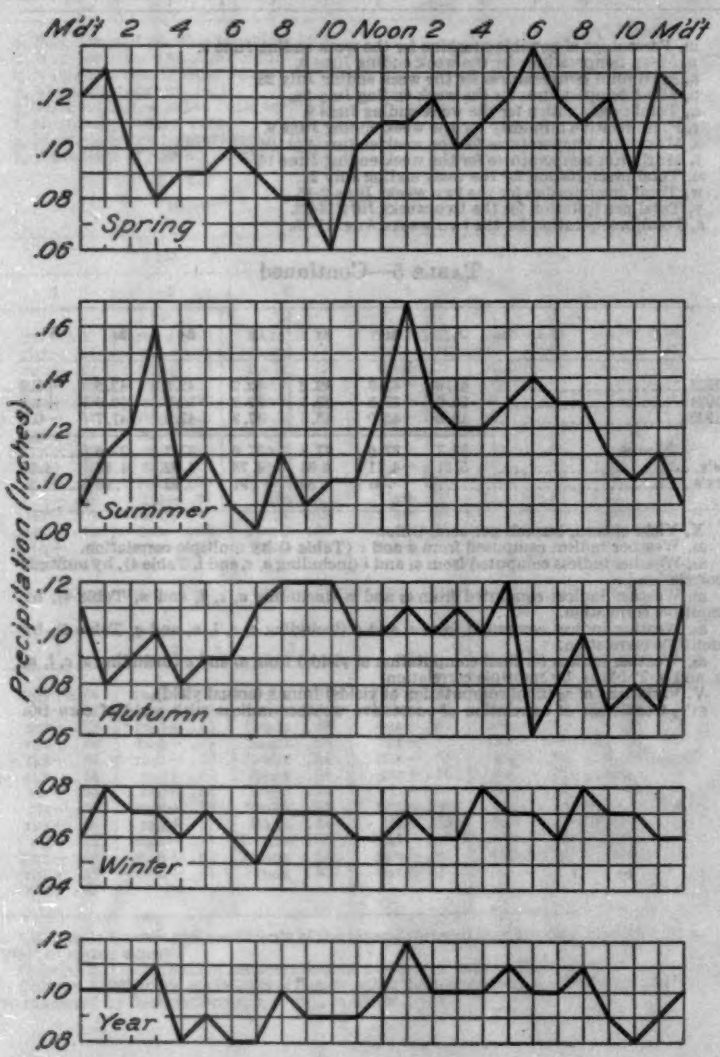


FIG. 1.—Average hourly precipitation at Memphis, Tenn., for the 20-year period, 1907–1926

the records were either prepared or verified by the same observer for practically the entire period.

Department-store sales and football games have been added to the growing list of weather insurance. The insurance companies recognize the fact that the hourly frequency of precipitation is greater during the winter months than during the summer by charging higher rates for December than July, etc.

Table 1 gives the total hourly precipitation for each hour by months for the 20-year period. Tables 2 and 3 show the average hourly precipitation and hourly fre-

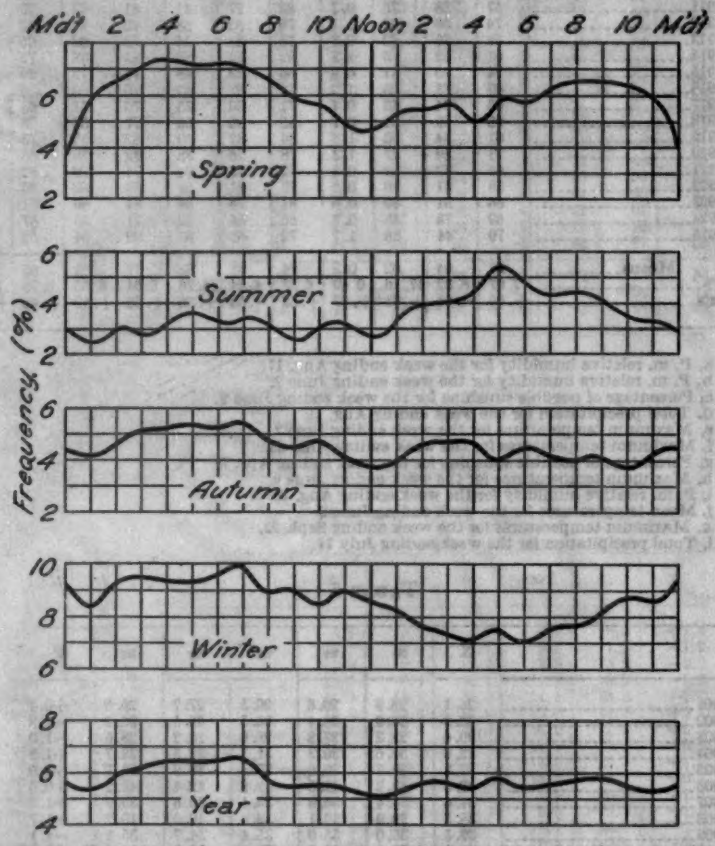


FIG. 2.—Percentage of hourly frequency of precipitation at Memphis, Tenn., for the 20-year period, 1907–1926

quency expressed in percentages. The vertical means in Table 2 were obtained by dividing the total hourly precipitation by the number of hours that 0.01 inch or more occurred; those in Table 3 were obtained by dividing the number of hours in which precipitation occurred by the total number of possible hours; the horizontal means in both tables were found by dividing the respective columns by 12. Table 4 gives the number of thunderstorms at Memphis during the 20-year period in percentages. On days with more than one thunderstorm all were counted.

Figure 1 shows the average hourly precipitation by seasons and the annual mean. Figure 2 shows the hourly frequency of precipitation by seasons and the annual mean.

A study of Tables 2 and 3 shows that the hourly precipitation is greater in summer than in winter but the hourly frequency is greater in winter than in summer.

To condense the tables we have the following:

	Average hourly precipitation	Hourly frequency
	Inches	*Per cent*
Spring	0.10	6.1
Summer	.12	3.5
Autumn	.10	4.5
Winter	.06	8.5

From the above it can be readily seen that the average hourly amount of precipitation in summer is twice as much as in winter. Spring and autumn have about the same average with spring being a little greater than autumn. The hourly frequency is greater in spring than in autumn while the frequency in winter is nearly two and one-half times greater than in summer.

Kincer showed that more precipitation occurred during the night than during the daytime. Taking the 12-hour periods ending at 7 a. m. as night and 7 p. m. as daylight hours it is found that there is no marked difference between the two periods for the 20-year record at Memphis. Using the means in Table 1 we have a total of 37.21 inches for the night hours and 37.02 inches for the daylight hours. The average hourly precipitation for the night hours is 0.09 and daylight hours 0.10 inches. The hourly frequency for the night hours is 5.9 per cent while the daylight hours is 5.4 per cent.

Figure 1 shows that the range of the hourly amounts is greater in spring and summer than in autumn and winter. This is probably due to thundershowers as 48 per cent of the thundershowers occur in summer, 27 per cent in spring, 14 per cent in autumn, and 11 per cent in winter.

TABLE 1.—*Total hourly precipitation at Memphis, Tenn., for the 20-year period, 1907 to 1926, inclusive*

MONTH	A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight
January	3.36	4.00	3.22	3.51	3.51	3.39	3.54	3.65	4.68	4.54	3.58	4.56	4.57	4.51	3.55	3.70	3.34	2.24	1.98	2.28	2.14	2.52	2.83	2.52
February	3.19	3.75	4.31	3.09	3.58	3.61	2.72	3.12	3.25	2.14	2.71	2.25	2.56	1.85	2.36	3.79	2.65	3.99	3.33	3.83	3.19	3.45	2.63	2.66
March	5.20	3.56	3.61	3.08	2.81	3.58	3.34	3.52	3.75	3.04	4.12	4.19	4.99	4.96	4.50	2.82	2.99	4.82	4.58	4.61	3.26	4.55	4.63	5.26
April	5.58	5.53	4.83	3.97	4.02	3.88	2.74	2.04	1.96	1.60	2.22	2.30	2.40	3.23	3.31	4.27	5.55	5.81	6.94	6.09	6.68	4.77	5.36	5.60
May	3.53	2.35	2.83	4.49	4.62	5.32	4.80	4.03	2.57	1.38	2.33	2.87	3.05	4.05	2.70	2.64	3.66	3.57	2.33	2.25	3.34	1.70	3.66	2.65
June	1.41	1.91	2.31	1.53	2.36	1.34	0.74	0.74	0.89	1.09	1.84	2.94	3.10	4.13	2.42	3.70	4.53	4.18	4.32	2.96	2.94	1.54	1.23	1.42
July	1.29	1.30	2.61	1.99	3.18	1.53	2.28	4.34	1.74	3.55	2.53	2.73	4.50	1.46	2.95	1.20	2.33	4.27	4.17	2.80	1.77	2.01	2.53	1.40
August	2.28	3.20	2.36	2.09	1.96	2.01	1.89	1.76	2.03	1.77	1.36	0.94	3.09	4.17	3.89	6.28	6.31	3.60	2.10	4.62	3.71	2.94	2.79	2.41
September	1.97	2.53	2.28	1.82	2.30	2.10	2.99	4.30	4.44	3.38	1.68	1.93	1.98	2.00	3.75	3.53	3.52	1.13	0.46	1.79	0.86	1.92	0.90	3.38
October	1.80	1.96	3.07	2.42	2.13	2.65	2.92	2.53	2.38	2.92	3.27	2.89	3.44	3.82	2.10	2.43	2.14	1.82	3.68	3.25	1.50	0.95	1.58	3.31
November	2.08	2.94	3.61	3.78	4.84	3.57	4.70	3.17	2.29	3.71	2.13	1.70	2.59	3.14	2.65	2.32	1.70	1.85	2.22	2.23	3.06	2.95	2.92	2.20
December	5.61	3.91	3.99	4.49	4.20	3.04	3.47	3.74	2.90	3.71	4.00	3.17	3.47	2.26	2.00	2.88	3.53	2.83	3.59	4.48	4.28	4.85	4.07	4.59
Mean	3.12	3.12	3.25	3.02	3.29	3.00	3.02	3.08	2.74	2.74	2.65	2.71	3.31	3.30	3.02	3.30	3.52	3.34	3.31	3.43	3.06	2.85	2.93	3.12

TABLE 2.—*Average hourly precipitation at Memphis, Tenn., for the 20-year period 1907 to 1926, inclusive*

Month	A. M.												P. M.												Mean
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight	
January	0.07	0.06	0.06	0.06	0.07	0.05	0.05	0.06	0.08	0.08	0.06	0.08	0.08	0.08	0.06	0.07	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.06
February	.07	.07	.08	.06	.07	.07	.06	.08	.08	.05	.06	.05	.07	.05	.07	.12	.09	.11	.08	.09	.07	.07	.05	.05	.07
March	.12	.08	.08	.07	.06	.07	.07	.07	.08	.06	.08	.11	.15	.13	.11	.09	.08	.12	.11	.10	.07	.10	.11	.13	.09
April	.14	.12	.10	.08	.10	.11	.08	.06	.07	.06	.10	.09	.08	.12	.09	.13	.14	.15	.15	.14	.15	.10	.13	.13	.11
May	.12	.10	.07	.11	.11	.12	.11	.11	.09	.05	.12	.12	.10	.12	.10	.10	.13	.14	.09	.09	.12	.08	.15	.10	.11
June	.11	.09	.09	.06	.11	.08	.05	.05	.07	.08	.14	.14	.15	.15	.11	.13	.11	.13	.15	.11	.12	.08	.08	.09	.11
July	.10	.07	.17	.10	.13	.07	.10	.20	.09	.13	.11	.15	.17	.07	.13	.07	.12	.14	.15	.14	.08	.07	.13	.08	.12
August	.12	.20	.21	.13	.10	.11	.08	.09	.11	.10	.06	.09	.18	.17	.13	.17	.17	.14	.09	.14	.12	.15	.11	.10	.13
September	.09	.12	.10	.06	.09	.10	.13	.19	.19	.13	.10	.12	.10	.09	.17	.13	.20	.05	.04	.11	.05	.08	.06	.15	.11
October	.08	.07	.10	.08	.08	.08	.09	.08	.10	.10	.11	.09	.14	.13	.07	.09	.09	.06	.14	.12	.08	.05	.05	.12	.09
November	.07	.08	.09	.10	.11	.09	.11	.09	.07	.12	.08	.08	.09	.09	.09	.08	.06	.07	.06	.08	.08	.10	.10	.07	.09
December	.09	.06	.06	.07	.06	.05	.05	.06	.05	.07	.07	.06	.07	.06	.05	.06	.07	.06	.06	.09	.08	.06	.07	.08	.06
Mean	.10	.10	.11	.08	.09	.08	.08	.10	.09	.09	.09	.10	.12	.10	.10	.10	.11	.10	.10	.11	.09	.08	.09	.10	.10

TABLE 3.—*Hourly frequency of precipitation at Memphis, Tenn., for the 20-year period 1907–1926, inclusive, in percentage*

Month	A. M.												P. M.												Mean
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight	
January	7.3	7.9	8.1	8.9	8.5	10.0	10.5	10.0	9.5	9.2	10.2	9.4	9.5	9.7	9.0	8.1	8.4	6.9	6.1	6.6	6.8	7.9	7.3	8.7	8.5
February	8.5	9.9	9.2	8.8	8.5	9.0	8.1	7.1	7.6	7.4	7.6	7.3	6.7	6.5	6.0	5.5	5.3	6.4	7.3	7.2	8.5	8.7	8.5	9.9	7.8
March	6.9	7.3	7.3	7.4	7.9	8.2	8.2	8.5	7.9	8.4	7.9	6.1	5.5	6.1	6.6	5.0	6.1	6.5	6.9	7.7	7.7	7.4	6.9	6.8	7.1
April	6.5	7.5	7.7	7.8	6.5	5.7	5.5	5.3	4.8	4.2	3.7	4.3	5.0	4.5	6.2	5.7	6.8	6.7	7.7	7.5	7.5	8.2	6.8	7.2	6.2
May	4.7	4.8	6.1	6.9	6.9	7.3	7.3	6.0	4.8	4.4	3.2	3.9	5.0	5.5	4.2	4.4	4.7	4.2	4.2	4.2	4.4	3.4	4.0	4.2	4.9
June	2.2	3.5	4.2	4.3	3.7	2.8	2.7	2.3	2.0	2.3	2.2	3.5	3.5	4.5	3.7	4.8	7.2	5.2	4.8	4.7	4.2	3.2	2.7	2.5	3.6
July	2.1	2.9	2.4	3.1	3.9	3.7	3.6	3.6	3.2	4.5	3.9	2.9	4.2	3.4	2.6	2.9	3.1	5.0	4.4	3.2	3.4	4.4	3.2	2.7	3.5
August	3.1	2.6	1.8	2.6	3.1	3.1	4.0	3.2	2.9	2.9	3.4	1.6	2.7	4.0	5.0	6.0	6.0	4.2	3.9	5.2	4.8	3.2	4.2	3.7	3.6
September	3.7	3.7	4.0	4.7	4.2	3.5	3.8	3.8	3.8	4.3	2.7	2.7	3.2	3.7	3.7	4.5	3.0	3.8	2.0	2.8	3.2	3.8	2.7	3.7	3.5
October	3.9	4.5	5.2	4.8	4.4	5.6	5.2	5.0	3.9	4.8	5.0	5.2	3.9	4.7	5.2	4.5	3.9	5.3	4.4	4.5	3.2	2.9	5.0	4.4	4.5
November	5.0	6.3	6.5	6.0	7.2	6.5	6.8	5.7	5.8	5.2	4.5	3.7	4.8	5.8	5.2	5.0	5.2	4.5	6.0	4.8	6.0	4.8	5.0	5.3	5.5
December	9.7	10.2	11.1	10.3	10.8	10.2	11.5	9.7	10.0	9.0	9.0	9.0	8.5	6.5	7.1	7.6	8.4	7.7	9.2	8.4	8.9	9.4	10.0	9.4	9.2
Mean	5.3	5.9	6.1	6.3	6.3	6.3	6.4	5.8	5.5	5.6	5.3	5.0	5.2	5.4	5.5	5.3	5.7	5.5	5.6	5.6	5.7	5.6	5.5	5.7	5.7

TABLE 4.—*Percentage of thunderstorms at Memphis, Tenn., for the 20-year period, 1907–1926, inclusive*

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P ct.	P. ct.	P. ct.	P. ct.	P. ct.
Midnight to 6 a. m.	1	1	2	1	2	2	2	1	1	1	1	0	15
6 a. m. to noon	1	1	2	2	1	2	3	2	2	0	0	1	17
Noon to 6 p. m.	1	1	1	3	4	9	8	9	4	1	1	1	43
6 p. m. to midnight	1	1	3	3	3	3	4	3	1	1	1	1	25
Sums	4	4	8	9	10	16	17	15	8	3	3	3	

METEOROLOGICAL SUMMARY FOR BRAZIL, JANUARY, 1928

By FRANCISCO SOUZA, Acting Director
[Directoria de Meterologia, Rio de Janeiro]

The secondary atmospheric circulation was rather abnormal; low pressure showed frequency and persistence that is not normal for this period of the year. Temperatures were generally high, especially in central Brazil, where there were periods of hot weather. In this region the rains were of torrential character and caused disastrous floods in certain rivers. Strong winds accompanying the areas of low pressure swept the southern part of the country during several periods and at times assumed the proportions of tempests, especially on the coast.

Rainfall was light in the northern and central regions; the deficiencies for these regions were 1.54 and 1.77 inches, respectively. In the southern region the precipitation was irregular with an average deficiency 0.98 inch.

Abundant rainfall in central Brazil during the last decade of the month was injurious to crops. The general condition of cotton, coffee, tobacco, cereals, and vegetables is good; that of sugar cane is bad. The harvesting of sugar cane and cereals is progressing, the gathering of cacao and the picking of cotton in the northern region have been completed. The soil is being prepared for cotton, cereals, sugar cane, and tobacco.

At Rio de Janeiro the weather was generally fine with only one period of rainy weather—28th to 31st. The means for pressure and temperature were slightly below normal. The rains were about normal excepting a fall of 2.58 inches on the 28th. The winds were generally fresh, moving predominantly from the southern quadrants. The maximum wind velocity was over 36 miles per hour from the south on the evening of the 28th.

NOTES

The influence of climatic conditions on the yield of wool in Argentina.—(By Guillermo Hoxmark [translated and abstracted by G. B. Diehl]).—Argentina is one of the foremost countries in the production of wool-bearing animals. According to the 1922 census it figured as third, and was superceded only by Australia and the United States. Consequently, Argentina's production of wool is of considerable importance in the world market.

In Table 1 are given eight countries which raise the largest number of sheep, according to the census of 1922.

TABLE 1

Countries	Number of head of wool-bearing animals	Countries	Number of head of wool-bearing animals
Australia	78, 803, 261	New Zealand	22, 222, 259
United States	36, 327, 000	British India	22, 082, 353
Argentina	36, 208, 981	Great Britain	20, 621, 165
Russia	31, 911, 200	Spain	19, 377, 427

The difference between the number raised in Argentina and the United States is insignificant, and it may be said that both of these countries rank second in the production of sheep in the world.

Variations in yields are important. For example, in Buenos Aires, the shearing of 1920–21 gave 3,500 grams as the mean weight of wool, and in 1925–26 the weight of this increased to 6,882 grams, making a difference of 3,332 grams between the yields from the two shearings. In Cordoba, there is a difference between the shearings of 1920–21 and 1925–26 of 4,100 grams, in favor of the last shearing.

With a view to investigating the influence of temperature on yield, Table 2 is given, by means of which the shearing results obtained during the five-year period 1920–21 to 1925–26 are shown.

TABLE 2

Provinces and States	Mean weight of wool	Indicator numbers	Mean annual temperature
	Grams		°*C.*
Rio Negro	4, 446	1, 000	12. 7
Buenos Aires	4, 431	1, 004	15. 3
Chubut	4, 094	1, 086	10. 1
La Pampa	3, 777	1, 177	15. 3
Santa Fe	3, 262	1, 363	18. 5
Cordoba	3, 210	1, 385	17. 4
La Rioja	3, 150	1, 411	18. 9
Entre Rios	3, 148	1, 412	18. 4
San Luis	2, 716	1, 637	16. 0
Corrientes	2, 588	1, 718	19. 7
Jujuy	2, 145	2, 072	14. 7
Salta	1, 672	2, 650	18. 5
Catamarca	1, 625	2, 736	20. 6

The mean largest yield was in Rio Negro, with 4,446 grams of fleece. Based on this yield were calculated the indicator numbers which appear in Table 2, column 3, in which Rio Negro has a basic indicator of 1,000, and the remaining States and Provinces higher numbers, indicating lower yields. The mean temperatures of the respective Provinces and States will be found in column 4 of Table 2, it being evident that there is a pronounced tendency to larger yields of wool with lower temperatures.

Chubut, which has a mean annual temperature of 10.1° C., should produce more wool per animal than any other southern region of the country, but, according to the statistics, Rio Negro and Buenos Aires produce more. This contradiction is owing, perhaps, to incomplete data during the first years, because the yield in Chubut in 1924–25 is the highest registered in the country, being 6,375 grams, which seems more logical.

A study of the influence of the atmospheric elements on the yield of wool in each Province and State of the country would be too extensive, consequently we shall consider only a limited number of these, choosing Corrientes, represented by the meteorological data of Con-

cepción (lat. 28° 25′ S., long. 57° 55′ W.); La Pampa, represented by General Acha (lat. 37° 22′ S., long. 64° 32′ W.); and Rio Negro, employing the data for Choele-Choel (lat. 39° 17′ S., long. 65° 38′ W.). There are marked differences in climate between the three places mentioned, as shown by the observations of mean monthly temperature and monthly precipitation for the period 1920–1926. (See Table 3.)

TABLE 3

Stations	Mean annual rainfall	Mean annual temperature
	Millimeters	° *C.*
Concepcion (Corrientes)	1,298	20.0
General Acha (La Pampa)	485	15.2
Choele-Choe (Rio Negro)	218	18.3

The mean annual precipitation of General Acha and Choele-Choel, compared with that of Concepcion, is 37 per cent and 17 per cent, respectively, while the difference in mean annual temperature is almost 5°. (See Table 3.)

Corrientes.—A preliminary analysis shows that the mean temperatures of the months of August and September, from 1920–21 to 1925–26, have the most pronounced correlation with the yield from the shearing in Corrientes. Low temperatures for these months have the effect of decreasing the yield of wool, while high temperatures have a contrary effect, and from this we believe that if the correlation found holds for the present year one could prognosticate for the shearing of 1926–27 a mean yield of 3,100 grams.

In the case of precipitation, that for the month of June gives the highest correlation with the yield. Much precipitation in that month appears to have a bad effect on the growth of wool. The absolute lack of rainfall in June, 1925, gave the highest yield registered, compensating the farmers to a certain extent for the losses suffered in cultivated crops from dryness. (The epoch of first shearing falls in October and November and that of the second in March and April.)

La Pampa.—As a result of the investigation a very high correlation was discovered between the mean temperature of April and May and the yield of wool, the higher temperatures being associated with a diminution in yield and vice versa. This correlation is between the mean weight of wool in grams in the State of La Pampa and the mean temperature for the months named at General Acha during the period 1920–1926. (The epoch of the second shearing falls in April.)

The correlation between the yield of wool and the precipitation in the month of October during the period 1920–1926 is almost perfect. It shows that much water is an obstacle to a good yield of wool, while little rainfall in that month is the most beneficial for the growth of fleece. (The first shearing is effected in the month of November.)

Using as a base the correlation established, there is a probability of a mean yield of 4,500 grams of fleece in La Pampa as a product of the shearings of 1926–27.

Rio Negro.—In order to study the correlation in this case the meteorological data of Choele-Choel were used, although perhaps it would have been better to have taken the data of some additional stations on the basis of an average.

The temperature and precipitation in March both exercise a greater influence than the other months of the year, low temperatures giving high yields and much precipitation being favorable.

In Rio Negro the rainfall for the month of March is very small. To judge from correlations between the meteorological factors and the yield from the shearing of 1926–27 it appears very probable that there will be approximately 5,900 grams of wool from the shearing of that period. (In this State the first shearing is in December and the second in April.)

A century of temperatures in Wisconsin.[1]—In this paper the author has collected the temperature observations made at 20 stations within a radius of about 200 miles of Madison, Wis., all of which at one time or another had a record of temperature observations made concurrently with those made at Madison. Each series was reduced to the mean of 24 hours, thus eliminating irregularities due to different hours of observations.

The average difference between the Madison observations and those of the surrounding stations was used to obtain an approximate mean temperature for Madison during those years when no observations were made at that station. As a check on the accuracy of the approximated monthly means for Madison the computations were carried out for 143 months when observations at Madison were available. For those months the approximate or estimated means differed from the observed means by less than a degree in 94 months, by less than 2° in 42 months, less than 3° in 5 months, and less than 4° in 2 months. The differences among the summer months were insignificant; the differences among the winter months probably may be explained as due to differences in instrumental exposure at Madison during the years 1878–1894. The final result is a table of monthly mean temperatures at Madison for each month of the period, 1819, October to December, 1926. Lack of space prevents us from reproducing the table, but we have excerpted the monthly means of the 10 warmest and coldest seasons, respectively.—*A. J. H.*

Seasonal temperature extremes in Wisconsin for 100 years

Warmest winters (December–February)		Coldest winters (December–February)		Warmest springs (March–May)		Coldest springs (March–May)	
	°*F.*		°*F.*		°*F.*		°*F.*
1877–78	31.8	1874–75	9.7	1878	50.1	1843	35.6
1881–82	29.5	1884–85	10.4	1825	49.5	1857	37.9
1879–80	27.8	1903–4	11.9	1833	49.4	1867	39.1
1889–90	27.4	1831–32	12.1	1839	49.3	1837	39.6
1875–76	26.3	1872–73	12.1	1921	49.3	1888	39.9
1920–21	26.3	1892–93	12.6	1830	49.0	1892	40.4
1832–33	26.2	1855–56	12.9	1844	49.0	1850	40.5
1918–19	26.0	1822–23	13.0	1910	49.0	1869	40.5
1844–45	25.6	1917–18	13.5	1880	48.9	1885	40.6
1862–63	25.5	1886–87	13.7	1842	48.9	1907	41.2

Warmest summers (June–August)		Coldest summers (June–August)		Warmest autumns (September–November)		Coldest autumns (September–November)	
	°*F.*		°*F.*		°*F.*		°*F.*
1830	73.3	1915	64.3	1830	53.4	1838	43.3
1901	73.1	1842	65.9	1922	52.8	1869	43.6
1921	73.1	1869	66.2	1920	52.3	1873	43.7
1825	72.3	1903	66.3	1879	51.7	1848	44.4
1828	72.3	1848	66.4	1914	51.7	1835	44.5
1823	72.2	1924	66.5	1882	51.5	1875	44.7
1874	72.1	1902	66.6	1897	51.5	1896	44.7
1838	71.9	1836	66.8	1908	51.5	1836	44.9
1854	71.9	1884	66.8	1865	51.3	1863	44.9
1894	71.9	1904	66.8	1870	51.1	1820	45.0

Two centuries of rain in England.—Dr. J. Glasspoole in Meteorological Magazine, February, 1928, discusses the

[1] Miller, Eric R. Transactions of the Wisconsin Academy of Sciences Arts, and Letters, Vol. XXIII, pp. 165–177, 1928.

rainfall in England back to 1727. In the early years there were but two records but these seem to have afforded dependable results.

The three wettest years of the period were 1768, 1852, and 1872, with 136, 137, and 144 per cent, respectively.

There was no years so dry as 1921 with only 69 per cent since 1788. The values for the years 1731, 1741, and 1743 were equally small, but since they are based on few records the presumption is that the departures from the normal were probably in excess of the true amount.

There were nine consecutive wet years from 1875 to 1883, but the longest run of dry years was only six, viz, from 1800 to 1805. The rainfall of the recent years is remarkable in that out of the last 14 but two, 1917 and 1921, received less than the average. The rainfall of 1927 was 124 per cent of the normal and was exceeded only by eight other years in the last 200. The three years 1768, 1852, and 1872 were markedly wetter than 1927.—*A. J. H.*

Comparison of precipitation at Northfield, Vt.[2]*—Greatest amount of precipitation, as shown, 41 years*

	24 hours		2 days		5 days		Monthly	
January	2.00	1891	2.00	1891	2.35	1888	4.99	1888
February	1.97	1900	1.97	1900	2.21	1896	4.85	1909
March	3.38	1919	3.62	1919	3.66	1919	6.41	1896
April	2.15	1895	2.68	1895	3.14	1895	5.12	1920
May	2.10	1916	2.81	1916	3.01	1912	6.87	1912
June	2.22	1926	2.22	1926	2.60	1903	7.88	1912
July	3.00	1905	3.37	1905	3.42	1897	8.04	1897
August	3.22	1918	3.34	1918	3.89	1918	6.98	1890
September	3.34	1920	3.60	1920	3.92	1888	6.27	1888 1924
October	3.00	1912	3.69	1912	3.88	1912	5.82	1917
November [3]	1.91	1924	2.20	1900	2.46	1895	5.68	1895
December	2.14	1887	2.33	1887	2.63	1895	5.88	1887
November	[4] 7.72	1927	8.40	1927	8.74	1927	11.42	1927

[2] Cf. November floods in New England and eastern New York this Review, 55: 496–499.

[3] Previous to 1927.

[4] The 24-hour precipitation on Nov. 3–4, 1927, was a little more than twice as great as had occurred in the previous 41 years.

—*W. A. Shaw.*

The problems of polar research.[1]—This volume of 479 pages contains 31 papers by recognized authorities on the various problems intimately associated with polar research. It fills the need of an up-to-date inventory of the results achieved by former explorers and offers a definite outline of the remaining unsolved problems.

The guiding principle in preparing the papers was not to emphasize either past achievements or heroic adventure but rather to concentrate on the major problems remaining to be solved by further field study, where and by what means these problems may best be attacked, and what manner of cooperation between the sciences most concerned may yield the greatest harvest of results.

It is of course not practicable in the space available to do justice to each of the 31 papers; I therefore content myself with presenting a table of authors and titles as below.

Contents of American Geographical Society's special publication No. 7

Group and author's name	Title of paper
Oceanographic:	
Fridtjof Nansen	The Oceanographic Problems of the Still Unknown Arctic Regions.
Erich von Drygalski	The Oceanographic Problems of the Antarctica.
H. A. Marmer	Arctic Tides.
Sir Douglas Mawson	Unsolved Problems of Antarctic exploration and Research.

[1] American Geographical Society, Special publication No. 7, edited by W. L. G. Joerg.

Contents of American Geographical Society's special publication No. 7—Continued

Group and author's name	Title of paper
Geological:	
A. P. Coleman	Unsolved Geological Problems of Arctic America.
I. P. Tolmachev	The Geology of the Arctic sea, Eurasia and Its Unsolved Problems.
R. E. Priestley and C. S. Wright.	Geological Problems of Antarctica.
Meteorology:	
H. H. Clayton	The Bearing of Polar Meteorology on World Weather.
Sir Frederic Stupart	The Influence of Arctic Meteorology on the Climate of Canada Especially.
Griffith Taylor	Climatic Relations between Antarctica and Australia.
Jules Rouch	The Meteorology of the American Quadrant of the Antarctic.
Ice problems:	
N. A. Transche	The Ice Cover of the Arctic Sea, with a Genetic Classification of Sea Ice.
A. Kolchak	The Arctic Pack and the Polynya.
R. E. Priestley and C. S. Wright.	Some Ice Problems of Antarctica.
Robert A. Bartlett	Ice Navigation.
Ethnology:	
Diamond Jenness	Ethnological Problems of Arctic America.
Waldemar Bogoras	Ethnographic Problems of the Eurasian Arctic.
Knud Rasmussen	Tasks for Future Research in Eskimo Culture.
Terrestrial magnetism:	
L. A. Bauer	Unsolved Problems in Terrestrial Magnetism and Electricity in Polar Regions.
Plant geography:	
John W. Harshberger	Unsolved Problems in Arctic Plant Geography.
Zoogeography:	
Leonhard Stejneger	Unsolved Problems of Arctic Zoogeography.
R. N. Rudmose Brown	Antarctic and sub-Antarctic Plant Life and Some of Its Problems.
Robert Cushman Murphy.	Antarctic Zoogeography and some of Its Problems.
Resources:	
Vilhjalmur Stefansson	The Resources of the Arctic and the Problems of Their Utilization.
Political Rights:	
David Hunter Miller	Political Rights in the Polar Regions.
Air Navigation:	
O. M. Miller	Air Navigation Methods in the Polar Regions.
Richard E. Byrd	Polar Exploration by Aircraft.
Geo. H. Wilkins	Polar Exploration by Airplane.
Lincoln Ellsworth	Arctic Flying Experiences by Airplane and Airship.
Umberto Nobile	The Dirigible and Polar Exploration.
Separate Illustration	Bathymetric Map of the Arctic Basin by Fridtjof Nansen revised to 1927. Scale 1 : 20,000,000.

Considering the group of papers on meteorology of the polar regions, a subject with which the present reviewer is more or less familiar, it may be said that the casual reader is apt to infer that the meteorology of the Antarctic is better known than that of the Arctic. That inference is not justifiable, although it is a fact that the observational material for the Arctic is much greater than for the Antarctic.

The failure to discuss the material for the Arctic is difficult of explanation except on the ground that the

observations were made about 40 years ahead of their time. Take, for example, the International Polar Observations of 1882–83. These have not been studied en masse and are perhaps mostly forgotten by meteorologists of the present generation. One is reminded of Professor Schuster's dictum, viz, that it would be a good thing for meteorology if the making of observations should be suspended for five years and the energy thus saved devoted to the study of observations already made.

In extenuation of the failure to discuss the observations above named, it should be remembered that in the early eighties the northern limit of the field of observation in the Northern Temperate Zone did not extend much, if any, above north latitude 55°, thus leaving a broad band of terra incognita, meteorologically speaking, between the very high latitude stations of the International Polar Observations and those of the North Temperate Zone. The same series of observations if made at present would have a much greater value than they now have.—*A. J. H.*

Manual of Meteorology, Volume II, Comparative Meteorology (by Sir Napier Shaw; Cambridge University Press, London, The Macmillan Co., New York, 1928).—Meteorologists are to be congratulated on the fact that the outstanding exponent of meteorological facts and theories among English-speaking peoples—Sir Napier Shaw, drawing upon his own knowledge and experience and having at his command that rich store of material to be found only in the British Meteorological Office—has taken the time and trouble to write a manual of meteorology for the use of present and unborn generations of men and women.

Volumes I and IV have already appeared. The explanation of why Volume IV appeared before Volume I is found in the fact that the material of that volume had a very direct bearing upon the military operations in the World War. It was printed in 1919, although the material had been assembled at an earlier date.

Volume I, Meteorology in History, came out in 1926 and the volume under review was printed in early 1928.

After presenting a very full history of the science from Aristotle's time up to the present in Volume I, Sir Napier presents in Volume II not only the nature and extent of the material that is available to the meteorological student but also his own conception of the larger problems of meteorology. The work is profusely illustrated by 225 maps and diagrams. It may be said of these that in view of the limitations imposed by the size of the volume (the letter-press is 19 by 12¼ cm.), an excellent presentation is made, although a few of the diagrams approach dangerously near to indistinctness owing to the reduction that was necessary. The major achievement, however, is the presentation, for the first time, of maps of both Northern and Southern Hemispheres having a diameter of but 14½ cm.

It is quite impossible, in the available space in this REVIEW, to more than browse around in the 10 chapters which make up the volume.

Chapter I deals with the influence of sun and space. Sir Napier recognizes that the fundamental causes of variations from the normal circulation are to be sought, in solar and terrestrial radiation, yet he is careful to point out that the details of the physical processes by which, for example, radiation is related quantitatively to temperature or its possible alternative vapor pressure are still in the stage of development that belong rather to the meteorological laboratory than to the normal observatory and accordingly the detailed consideration of the subject must be postponed for the present. He presents as useful working data A. Angot's distribution of solar energy which would reach unit area of receiving surface at right angles to the sun's rays at the outer limit of the atmosphere. The week is the time unit used.

Chapter II, 26 pages, deals with the distribution of land, water, and ice, orographic features, and other geophysical agencies, and Chapter III with the composition of the atmosphere.

Chapter IV, 83 pages, is devoted to temperature; the monthly mean values are chosen as the basis of presentation. A set of monthly and annual maps of normal temperature at sea level, 26 maps in all, are figured and these are supplemented by maps of the average daily range of temperature throughout the year and also the normal temperature within the cycle of the seasons in different parts of the world.

A space of about 4¼ by 14 cm. is available under each hemispherical map. These spaces have been utilized for the presentation of some of the multitudinous facts about average conditions of temperature.

The temperature of the free air is naturally treated in less detail by reason of insufficient data. The chapter concludes with a bibliography as do several others.

Chapter V, 82 pages, is devoted to a discussion of the problems that arise in relation to the vapor content of the atmosphere and condensation thereof in the form of rain or snow. The vertical distribution of water vapor is considered as is also evaporation from land and water surfaces as measured at many stations over the globe A table of observed annual values is given.

Chapter VI, 79 pages, is devoted to a consideration of pressure and winds. In this chapter barometric observations in all parts of the world are represented by maps of normal monthly isobars or lines of equal pressure. Owing to the well-known relation between the wind and the pressure distribution, the normal conditions as to wind or the normal resultant flow of air is easily recognized.

Then follows a discussion of the general relation of winds to the isobars and thus to some general ideas of the circulation of air over the globe. Trade winds and monsoon winds are discussed in some detail. Sir Napier, rightly we believe, frowns upon the practice of some writer not all of whom reside on the other side of the Atlantic, of applying the term "monsoon" indiscriminately to any wind that has a seasonal variation. He says:

> It is an unnecessary and an unfortunate habit, not only because the name "monsoon" has been attributed from the very earliest times to part of a certain definite cyclonic circulation, but also because practically everything meteorological is seasonal, but is not on that account monsoonal.

The sixth chapter completes the picture of the normal general circulation of the atmosphere and its seasonal variations. In the remaining chapters the author turns his attention to the changes disclosed by differences in the values from which the means of the several months have been obtained.

Chapter VII, 49 pages, discusses changes in the general circulation resilience or plasticity, in which the ideas of plasticity and resilience of the circulation is developed.

From one point of view the circulation may be looked on as a plastic structure which, like clay, can be molded by the external influences that are operative from time to time. It may be supposed to have no resilience but simply a capacity for taking the impress of disturbing causes. The other point of view depends ultimately on the idea that the circulation as a whole is a resilient struc-

ture. It may be disturbed by any temporary exceptional cause such as some peculiarity of the orbits of the sun, moon, or planets, a change in the solar energy, or a loss of transparency of the atmosphere on account of dust or carbonic-acid gas, an accumulation of ice in the polar region, or a recession of the glaciers of lower latitudes, and so on, when the temporary cause is removed and the conditions are restored to normal (if that be possible) the circulation will, in virtue of resilience, recover its normal condition; but it may oscillate about the normal in some period or periods of its own before resuming the normal state. * * * Both of these ideas are fully developed.

Chapter VIII, 35 pages, discusses the transitory variations of pressure cyclones and anticyclones, and that section is followed by a discussion of the structure of cyclonic depressions in which some of the newer views find place.

Finally Chapter X, 20 pages, on the earth's atmosphere brings to a close Sir Napier's exposition of the structure of the earth's atmosphere, the general circulation, and its variations of long or short period. This chapter forms in his own words "the brass plate, bell pull, and knocker of the house which is to be represented by the remaining volumes."

No student of meteorology can afford to be without this manual.—*A. J. H.*

February weather in the United States 50 years ago.—The month was characterized by very low atmospheric pressure in Pacific Coast States and adjoining oceanic areas, the large number of rainstorms that came in from the Pacific, damaging floods in Pacific Coast States, dry weather east of the Rockies, high temperatures in the interior of the continent, and stormy weather in the Atlantic off the Virginia and North Carolina coast. A few tornadoes occurred in the Gulf States. On the whole, great diversity in the weather ruled.—*A. J. H.*

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

American railway engineering association.

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING FEBRUARY, 1928

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, **52**: 42, January, 1925, **53**: 29, and July, 1925, **53**: 319.

Table 1 shows that solar radiation intensities were close to the normal values for February at Washington, D. C., and Madison, Wis., and above the normal at Lincoln, Nebr.

Table 2 shows a slight excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky at Washington, and a deficiency at Madison and Lincoln, as compared with the February normals for these stations.

Skylight polarization measurements at Washington made on three days give a mean of 59 per cent, with a maximum of 53 per cent on the 28th. These are close to the corresponding normal values for Washington for February. At Madison no polarization measurements were made during the month on account of the presence of ice and snow.

TABLE 1.—*Solar radiation intensities during February, 1928*

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance: Sa. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Washington, D. C.											
Feb. 1	3.63				1.06						3.81
2	1.19	0.85	0.98	1.14	1.31						1.78
4	3.63		0.61	0.75	1.11		1.12	0.87			4.37
6	1.68				1.13						2.06
9	4.57				1.31						3.45
11	3.30		0.71								3.45
21	1.19	0.53	0.67	0.91	1.22	1.57	1.12	0.91	0.72	0.58	1.12
27	1.96	0.83	0.93	1.09	1.27	1.55	1.26	0.99	0.90	0.71	2.02
28	3.30	0.65	0.75	0.90	1.06						2.02
Means		0.72	0.78	0.96	1.18	(1.56)	1.17	0.92	(0.81)	(0.64)	
Departures		+0.01	−0.03	−0.02	+0.01		−0.02	−0.05	−0.03	−0.12	
Madison, Wis.											
Feb. 1	1.19		1.07	1.23	1.44	1.67		1.29			1.19
3	2.49				1.20			1.06			3.45
9	2.87	1.04	1.15	1.28	1.44	1.63	1.44	1.25			2.74
11	3.45	0.98	1.06	1.16	1.30	1.47					3.30
20	1.02						1.28				0.81
23	1.60						1.46				0.81
24	1.12		1.12	1.27	1.42	1.62					0.79
25	0.64		1.06	1.22	1.37						0.86
27	2.36			1.25	1.43	1.55	1.42				2.49
Means		(1.01)	1.10	1.24	1.37	1.55	1.40	1.20			
Departures		+0.06	−0.01	+0.01	±0.00		+0.03	+0.02			
Lincoln, Nebr.											
Feb. 1	1.07	0.51	0.82	1.25				1.23	1.04	0.93	1.45
9	2.87							1.21			3.63
10	3.45		1.04	1.24							3.81
16	1.96			1.30	1.46	1.63					2.16
19	3.15		1.04	1.20	1.32	1.45					3.00
23	0.86		1.16	1.29	1.47	1.68	1.49	1.33	1.21	1.10	0.96
24	0.96	1.02	1.19	1.30	1.45						1.19
27	2.16	0.99	1.14	1.30	1.43						2.36
Means		0.84	1.06	1.27	1.43	1.59	(1.49)	1.26	(1.12)	(1.02)	
Departures		−0.11	+0.11	+0.06	+0.05		+0.14	+0.08	+0.06	+0.10	

[1] Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation: Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Average daily departure from normal: Washington	Madison	Lincoln
1928	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Jan. 29	252	186	214	107	160	[1] 150	+56	−5	−21
Feb. 5	158	170	211	108	156	200	−45	−37	−48
Feb. 12	175	194	250	87	114	282	−47	−36	−35
Feb. 19	298	291	297	153	277	243	+47	+39	−12
Excess or deficiency since first of year on Feb. 25							+189	−511	−770

[1] Six-day mean.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory]

Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories]

(The differences of longitude measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column)

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1928	h. m.	°	°	°			
Jan. 18 (Harvard)	12 55	−53.0	143.5	+17.0	------	1,280	------
		+6.0	202.5	+18.5	17	------	------
		+6.5	203.0	+14.5	15	------	------
		+76.5	273.0	−11.0	------	248	1,660
Jan. 24 (Harvard)	10 42	−79.0	39.5	−14.5	144	------	------
		−72.5	46.0	−19.5	------	359	------
		−23.0	95.5	+9.0	68	------	------
		−14.5	104.0	+8.0	80	------	------
		−6.5	112.0	+6.5	------	402	------
		+8.5	127.0	+11.0	------	111	------
		+25.5	144.0	+16.0	------	302	1,406
Jan. 30 (Harvard)	15 7	−3.0	34.0	−10.5	45	------	------
		−1.0	36.0	−7.0	330	------	------
		+8.0	45.0	−21.5	------	363	------
		+36.0	73.0	−11.0	------	167	------
		+69.5	106.5	+8.0	------	737	1,642
Feb. 1 (Naval Observatory)	11 50	−66.0	306.4	+9.0	------	62	------
		−55.5	316.9	−18.5	31	------	------
		−31.5	340.9	+15.0	------	31	------
		+22.5	34.9	−7.5	247	------	------
		+32.0	44.4	−22.0	------	309	------
		+63.0	75.4	−11.0	93	------	775
Feb. 2 (Naval Observatory)	11 45	−80.0	279.2	−11.0	------	123	------
		−72.5	286.7	−11.0	------	93	------
		−52.0	307.2	+8.5	31	------	------
		−43.5	315.7	−17.5	------	15	------
		+37.0	36.2	−8.0	231	------	------
		+45.0	44.2	−21.5	------	247	------
		+77.0	76.2	−11.0	62	------	802
Feb. 3 (Naval Observatory)	11 48	−68.0	278.0	−11.0	------	108	------
		−59.0	287.0	−11.5	77	------	------
		−39.5	306.5	+9.0	31	------	------
		−32.0	314.0	−17.5	------	15	------
		+50.5	36.5	−8.0	247	------	------
		+57.5	43.5	−21.5	278	------	------
		+73.0	59.0	+1.5	------	46	802
Feb. 4 (Naval Observatory)	11 48	−55.0	277.0	−11.0	31	------	------
		−45.5	287.4	−11.0	62	------	------
		+63.0	35.0	−8.0	278	------	------
		+71.0	43.9	−21.5	------	309	680
Feb. 5 (Yerkes)	16 1	−37.0	283.0	−14.0	75	------	------
		−28.0	292.0	−14.0	75	------	150
Feb. 6 (Naval Observatory)	11 47	−56.5	250.1	−22.0	28	------	------
		−35.0	271.6	−19.5	------	15	------
		−28.0	278.6	−11.0	25	------	------
		−18.0	288.6	−11.0	46	------	111
Feb. 7 (Mount Wilson)	14 0	−42.0	250.1	−23.0	------	37	------
		−31.0	271.1	−19.0	------	12	------
		−8.0	294.1	−12.0	------	55	104
Feb. 8 (Mount Wilson)	14 15	−29.5	249.4	−23.0	------	29	------
		+10.0	288.9	−12.0	44	------	73
Feb. 9 (Naval Observatory)	11 47	+14.0	261.0	−11.5	------	31	------
		+21.5	268.5	−13.5	------	31	62

Date	Eastern standard civil time	Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
	h. m.	°	°	°			
Feb. 10 (Naval Observatory)	11 46	−46.0	207.9	+17.5	------	77	------
		+28.0	281.9	−12.0	------	62	------
		+34.5	288.4	−12.5	31	------	170
Feb. 11 (Mount Wilson)	13 45	−33.0	206.5	+18.0	------	137	------
		+34.0	273.5	+11.0	------	29	------
		+46.0	285.5	−12.0	------	18	184
Feb. 12 (Naval Observatory)	11 44	−18.0	209.6	+17.5	------	216	------
		+45.0	272.6	+11.0	------	31	------
		+49.0	276.6	+11.5	77	------	324
Feb. 13 (Naval Observatory)	11 46	−80.5	133.9	−22.0	77	------	------
		−9.0	205.4	+18.5	------	93	------
		−0.5	213.9	+16.5	108	------	------
		+57.5	271.9	+11.0	------	77	------
		+62.0	276.4	+11.5	108	------	463
Feb. 14 (Harvard)	11 37	−65.5	136.0	−22.5	100	------	------
		−61.0	140.5	+21.0	------	66	------
		+8.5	210.0	+17.5	------	99	------
		+77.5	279.0	+11.5	------	452	717
Feb. 14 (Mount Wilson)	12 45	−81.0	119.7	+19.5	------	40	------
		−66.0	134.7	−22.0	29	------	------
		−63.0	137.7	+20.5	------	32	------
		+9.5	210.2	+18.0	------	125	------
		+76.0	276.7	+11.5	------	296	522
Feb. 15 (Naval Observatory)	11 47	−77.0	111.0	+6.5	------	802	------
		−62.0	126.0	+19.5	------	46	------
		−53.0	135.0	−22.0	43	------	------
		−48.0	140.0	+20.5	------	31	------
		+16.0	204.0	+18.5	------	31	------
		+27.0	215.0	+16.5	108	------	------
		+66.0	274.0	+11.0	62	------	1,123
Feb. 16 (Mount Wilson)	11 0	−67.0	108.0	+6.0	------	770	------
		−54.0	121.0	+19.5	------	66	------
		−41.0	134.0	−22.0	26	------	------
		−39.0	136.0	+21.0	28	------	------
		−18.0	157.0	−10.0	------	97	------
		+35.0	210.0	+18.0	------	97	1,084
Feb. 17 (Mount Wilson)	11 45	−54.0	108.8	+8.0	------	1,409	------
		−38.0	124.8	+20.5	------	87	------
		−28.0	134.8	−22.0	12	------	------
		−24.0	138.8	+21.0	------	25	------
		−10.5	152.3	−17.0	------	44	------
		−5.0	157.8	−10.0	------	184	------
		+53.0	215.8	+17.0	------	116	1,877
Feb. 17 (Harvard)	11 45	−49.5	112.5	+5.5	------	995	------
		−39.0	123.0	+19.0	11	------	------
		−32.5	129.5	+18.5	------	19	------
		−9.5	152.5	−17.0	------	39	------
		−3.0	159.0	−9.5	------	75	------
		+52.5	214.5	+15.5	------	107	1,246
Feb. 18 (Naval Observatory)	11 39	−38.5	110.1	+7.5	432	------	------
		−37.0	111.6	+4.5	------	463	------
		−29.0	119.6	+19.5	15	------	------
		−23.5	125.1	+10.0	6	------	------
		−21.0	127.6	+19.0	------	31	------
		−9.5	139.1	+20.5	------	31	------
		+1.5	150.1	−17.5	------	15	------
		+5.5	154.1	−17.0	25	------	------
		+5.0	153.6	−9.5	------	31	------
		+10.5	159.1	−9.5	93	------	------
		+61.0	209.6	+17.0	------	108	1,250
Feb. 19 (Naval Observatory)	11 44	−80.0	55.4	−12.0	123	------	------
		−25.0	110.4	+7.5	340	------	------
		−23.0	112.4	+4.5	------	340	------
		+3.5	138.9	+20.5	------	123	------
		+17.5	152.9	−17.5	------	123	------
		+19.5	154.9	−9.5	31	------	------
		+25.0	160.4	−10.0	108	------	1,188
Feb. 20 (Naval Observatory)	12 54	−82.0	39.6	−20.0	93	------	------
		−65.0	56.6	−12.0	123	------	------
		−12.0	109.6	+3.5	------	123	------
		−11.0	110.6	+7.5	309	------	------
		−7.5	114.1	+5.0	------	185	------
		+2.0	123.6	−23.0	------	77	------
		+17.5	139.1	+21.0	------	46	------
		+31.0	152.6	−17.5	------	170	------
		+39.5	161.1	−10.0	93	------	1,219
Feb. 21 (Naval Observatory)	12 7	−72.0	36.9	−8.5	247	------	------
		−60.0	39.9	−20.0	123	------	------
		−57.0	41.9	−5.0	46	------	------
		−50.0	48.9	−9.0	31	------	------
		−51.5	57.4	−11.5	------	123	------
		+0.5	109.4	+3.5	------	123	------
		+2.0	110.9	+7.5	293	------	------
		+7.0	115.9	+4.5	------	123	------
		+15.0	123.9	−22.5	------	77	------
		+44.0	152.9	−17.0	------	154	------
		+51.0	159.9	−10.0	108	------	1,448
Feb. 22 (Naval Observatory)	11 43	−59.0	36.9	−8.5	185	------	------
		−56.0	39.9	−20.0	108	------	------
		−53.5	42.4	−5.0	31	------	------
		−46.5	49.4	−9.0	9	------	------
		−44.0	51.9	−16.0	------	31	------
		−37.5	58.4	−10.5	------	93	------
		+14.5	110.4	+3.0	------	123	------
		+15.0	110.9	+7.5	309	------	------
		+19.0	114.9	+5.0	------	62	------
		+28.0	123.9	−22.0	------	77	------
		+51.5	147.4	−17.5	------	46	------
		+61.0	156.9	−17.5	------	108	------
		+64.5	160.4	−10.0	108	------	1,290

Date	Eastern standard civil time	Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
	h. m.	°	°	°			
Feb. 23 (Naval Observatory)	13 0	−44.5	37.5	−8.5	123	------	------
		−41.5	40.5	−19.5	123	------	------
		−29.5	52.5	−16.0	------	31	------
		−26.0	56.0	−12.0	------	40	------
		−21.5	60.5	−10.0	------	46	------
		+28.0	110.0	+3.5	------	31	------
		+29.0	111.0	+7.5	293	------	------
		+32.0	114.0	+4.0	------	40	------
		+44.0	126.0	−23.0	------	154	------
		+48.5	130.5	+12.0	------	15	------
		+54.5	136.5	+21.0	------	62	------
		+67.0	149.0	−17.0	------	62	------
		+75.0	157.0	−18.0	------	77	------
		+79.0	161.0	−10.0	62	------	1,159
Feb. 24 (Naval Observatory)	14 28	−30.0	38.0	−8.5	139	------	------
		−28.0	40.0	−20.0	93	------	------
		−14.5	53.5	−15.0	15	------	------
		−7.5	60.5	−10.5	------	62	------
		+7.0	75.0	−25.5	31	------	------
		+42.5	110.5	+7.5	293	------	------
		+43.0	111.0	+3.5	------	62	------
		+55.5	123.5	−26.5	77	------	------
		+58.0	126.0	−22.0	------	93	------
		+60.0	128.0	+12.0	31	------	------
		+81.0	149.0	−17.5	------	123	1,019
Feb. 25 (Harvard)	0 52	−16.5	41.0	−7.5	241	------	------
		−14.5	43.0	−19.0	184	------	------
		+6.5	64.0	−10.0	------	195	------
		+56.0	113.5	+6.5	------	418	1,038
Feb. 25 (Mount Wilson)	14 15	−80.0	335.0	+18.0	62	------	------
		−18.0	37.0	−8.0	137	------	------
		−16.0	39.0	−19.5	100	------	------
		−3.0	52.0	−16.0	6	------	------
		+6.0	61.0	−11.0	------	195	------
		+20.0	75.0	−27.0	------	18	------
		+59.5	114.5	+6.0	------	348	------
		+69.0	124.0	−26.0	------	104	970
Feb. 26 (Naval Observatory)	11 50	−79.0	324.2	−8.0	------	154	------
		−67.5	335.7	−19.5	93	------	------
		−60.0	343.2	−17.5	------	31	------
		−5.0	38.2	−8.5	139	------	------
		−2.5	40.7	−19.5	108	------	------
		+19.0	62.2	−11.5	------	494	------
		+30.5	73.7	−26.0	------	93	------
		+68.5	111.7	+7.5	278	------	1,390
Feb. 27 (Naval Observatory)	11 54	−67.0	323.0	−7.0	185	------	------
		−54.0	336.0	−19.5	77	------	------
		−47.0	343.0	−18.5	------	93	------
		+8.0	38.0	−8.5	139	------	------
		+10.5	40.5	−19.5	93	------	------
		+23.0	53.0	−4.5	------	77	------
		+30.0	60.0	−11.5	------	340	------
		+36.0	66.0	−12.0	309	------	------
		+40.0	70.0	−28.0	------	46	------
		+46.5	76.5	−25.5	------	46	------
		+82.0	112.0	+7.5	309	------	1,714
Feb. 28 (Naval Observatory)	11 47	−57.5	319.3	−7.0	6	------	------
		−53.0	323.8	−6.5	185	------	------
		−41.0	335.8	−19.5	43	------	------
		−33.5	343.3	−18.5	------	77	------
		+21.0	37.8	−9.0	139	------	------
		+22.0	38.8	−19.5	77	------	------
		+36.5	53.3	−4.5	------	185	------
		+42.0	58.8	−11.5	------	278	------
		+48.0	64.8	−12.5	278	------	------
		+55.5	72.3	−27.0	------	77	1,345
Feb. 29 (Naval Observatory)	11 37	−50.5	313.2	−7.5	------	62	------
		−40.0	323.7	−6.0	247	------	------
		−28.5	335.2	−19.5	37	------	------
		−21.5	342.2	−19.5	31	------	------
		−18.0	345.7	−19.0	------	40	------
		+34.0	37.7	−8.5	108	------	------
		+35.5	39.2	−19.0	77	------	------
		+48.5	52.2	−4.0	------	247	------
		+55.0	58.7	−11.0	------	185	------
		+61.5	65.2	−12.5	494	------	------
		+65.0	68.7	−28.0	------	31	1,559
Mean daily area for February							851

PROVISIONAL SUN SPOT RELATIVE NUMBERS FOR FEBRUARY, 1928

[Data furnished by Prof. A. Wolfer, University of Zurich, Switzerland]

February	Relative numbers	February	Relative numbers	February	Relative numbers
1	------	11	28	21	109
2	49	12	38	22	130
3	66	13	------	23	140
4	31	14	28	24	89
5	48	15	------	25	109
6	------	16	70	26	99
7	35	17	77	27	129
8	30	18	70	28	110
9	23	19	109	29	96
10	32	20	120		

Number of observations, 25; mean, 74.6.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

The free-air temperatures were, in general, above normal at the northern stations and below normal at the southern stations. From Table 1 it will be seen that the greatest positive departures occurred at Ellendale and the greatest negative departures in the lower levels at Due West and at 1,000 m. and 1,250 m. above Groesbeck. This distribution is in general agreement with the surface departures shown in Chart I of this REVIEW.

Relative humidity departures were mostly small, the largest values occurring at Ellendale, where they were consistently below normal in accordance with the positive temperature departures, and at Broken Arrow, where they were all positive and likewise in accordance with the negative temperature departures there.

Departures of vapor pressure for the month were unusual at Broken Arrow and Ellendale in that they were of *opposite* sign from those for temperature. At the former station, where temperatures were below normal and vapor pressures above, it is interesting to observe that the total amount of precipitation for the month was 2.09 inches, the largest on record for February. Likewise, at Ellendale where supernormal free-air temperatures occurred and subnormal vapor pressures, the total precipitation for the month (0.23 inch) was the lowest for February with a single exception since the establishment of the station in 1917.

From Table 2 it will be seen that the resultant wind velocities for the month were close to their normals in most cases. The largest deviations from the resultant directions occurred at Due West and Groesbeck, where a northerly component prevailed instead of the normal southerly at a number of levels.

Pilot balloon observations revealed easterly winds at altitudes ranging from 3 km. to the Cirrus level from the 8th to 11th, inclusive, at a number of western stations, viz, Cheyenne, Salt Lake City, Sheridan, Modena, Boise, Reno, and San Francisco. Easterly winds at such high elevations are unusual during the winter season in these latitudes and indicate a general reversal of the horizontal pressure and temperature gradients at these heights. During this period a high-pressure area prevailed over the Pacific Ocean and impinged on the North Pacific Coast States. As a portion of this high became detached from the major section abnormally low surface temperatures were carried southeastward while relatively high temperatures prevailed to the northward, resulting in a reversal of the normal horizontal pressure gradient at these upper levels and the easterly winds observed.

An excellent example of cold underrunning air superimposed by an unusually pronounced temperature inversion is shown in the kite record of Groesbeck for the 23d. At the time a strong high-pressure area had just reached that region and surface temperatures were falling rapidly. The morning kite flight showed a surface temperature of 3.6° C., with a lapse rate of 0.78° per 100 m. to an altitude of 600 m., where the temperature was −1.2° C. Throughout the next 500 m. layer the temperature rose 12.6°, i. e., to 11.4° C. At an altitude of 2,500 m. the temperature was still no lower than at the surface. Such abnormal vertical temperature gradients are rare in this latitude and occur only when strong anticyclones invade these regions.

TABLE 1.—*Free-air temperatures, relative humidities and vapor pressures during February, 1928*

TEMPERATURE (°C)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C. (7 meters)[1]	
	Mean	Departure from 10-yr. mean	Mean	Departure from 7-yr. mean	Mean	Departure from 11-yr. mean	Mean	Departure from 10-yr. mean	Mean	Departure from 10-yr. mean	Mean	Departure from 3-yr. mean
Meters												
Surface	5.1	−0.4	5.9	−2.6	−7.4	+1.8	8.8	−1.6	−1.0	+0.1	3.9	+0.5
250	5.1	−0.3	5.8	−2.5	------	------	8.1	−1.9	−1.2	+0.1	2.1	−0.1
500	4.0	−0.3	5.4	−1.8	−7.5	+1.8	7.0	−2.1	−2.8	+0.3	1.1	−0.4
750	3.1	−0.5	5.4	−1.0	−7.6	+1.3	6.1	−2.6	−3.6	+0.2	−0.2	−0.5
1,000	2.4	−1.0	5.0	−0.6	−7.5	+0.7	6.2	−2.3	−4.3	−0.2	−1.6	−0.6
1,250	1.7	−1.4	4.3	−0.4	−7.6	+0.1	6.2	−1.7	−5.0	−0.5	−2.9	−0.8
1,500	1.2	−1.2	3.6	−0.2	−7.8	−0.2	5.4	−1.7	−5.9	−0.9	−4.4	−1.5
2,000	−0.5	−1.3	2.1	+0.2	−9.2	−0.2	3.2	−1.8	−7.8	−1.4	−6.8	−1.0
2,500	−2.5	−1.0	−0.4	+0.1	−11.1	+0.2	1.2	−1.4	−9.5	−1.2	−7.6	−1.8
3,000	−5.1	−1.0	−2.5	+0.4	−13.5	+0.5	−1.5	−1.7	−11.8	−1.0	−9.7	−1.1
3,500	−7.3	−0.7	------	------	−16.4	+0.3	−3.7	−1.5	−14.4	−0.8	------	------
4,000	−10.1	−0.8	------	------	------	------	−5.2	−0.5	------	------	------	------
4,500	−13.0	−0.7	------	------	------	------	−8.4	−1.0	------	------	------	------
5,000	−15.7	−0.7	------	------	------	------	------	------	------	------	------	------

RELATIVE HUMIDITY (%)

Surface	79	+2	70	+2	75	−6	72	−1	76	−1	66	−5
250	70	+2	69	+1	------	------	71	0	76	−1	64	−4
500	68	+3	64	−1	74	−6	67	−1	76	−1	66	−2
750	65	+4	62	−1	67	−7	65	+1	75	+1	63	−2
1,000	63	+7	62	0	62	−7	69	0	69	0	65	0
1,250	62	+9	69	+2	55	−9	54	−1	65	+1	66	0
1,500	57	+6	58	−1	51	−9	52	+1	62	+1	63	+2
2,000	51	+4	55	−1	45	−12	48	+2	54	−2	60	+1
2,500	50	+4	57	+2	42	−15	48	+5	46	−5	52	−3
3,000	50	+5	45	−7	42	−14	44	+3	50	−5	78	+23
3,500	53	+9	------	------	42	−12	37	−2	51	−4	------	------
4,000	55	+11	------	------	------	------	35	−1	------	------	------	------
4,500	48	+6	------	------	------	------	35	+3	------	------	------	------
5,000	48	+6	------	------	------	------	------	------	------	------	------	------

VAPOR PRESSURE (*mb.*)

Surface	6.70	+0.29	6.73	1.38	2.78	+0.10	8.50	−1.22	4.61	0.00	5.42	−0.16
250	6.66	+0.30	6.62	1.37	------	------	8.06	−1.23	4.54	0.00	4.76	−0.22
500	6.09	+0.46	5.95	1.19	2.70	+0.07	7.12	−1.25	4.10	+0.00	4.36	−0.16
750	5.56	+0.62	5.83	0.82	2.33	−0.13	6.53	−1.07	3.90	+0.25	4.02	−0.14
1,000	5.24	+0.77	5.67	0.56	2.13	−0.25	6.00	−0.77	3.37	+0.08	3.73	−0.07
1,250	4.81	+0.77	5.40	0.33	1.90	−0.30	5.37	−0.68	2.89	−0.02	3.41	−0.09
1,500	4.33	+0.62	4.77	0.39	1.72	−0.41	4.84	−0.42	2.57	−0.03	3.06	−0.11
2,000	3.25	+0.40	3.84	0.27	1.48	−0.30	3.77	−0.30	1.89	−0.18	2.36	−0.21
2,500	2.73	+0.39	3.15	0.12	1.24	−0.23	3.22	−0.05	1.67	−0.04	1.66	−0.25
3,000	2.14	+0.24	1.88	0.64	1.03	−0.12	2.30	−0.41	1.55	+0.18	2.26	+0.71
3,500	1.98	+0.39	------	------	0.90	+0.01	1.57	−0.64	1.47	+0.38	------	------
4,000	1.70	+0.38	------	------	------	------	1.42	−0.32	------	------	------	------
4,500	1.38	+0.22	------	------	------	------	1.30	+0.02	------	------	------	------
5,000	1.20	+0.39	------	------	------	------	------	------	------	------	------	------

[1] Naval air station, Anacostia, D. C.

TABLE 2.—*Free-air resultant winds (m. p. s.) during February, 1928*

Altitude m. s. l.	Broken Arrow, Okla. (253 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		10-year mean		Mean		7-year mean		Mean		11-year mean		Mean		10-year mean		Mean		10-year mean		Mean		8-year mean	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	S. 77 W.	1.2	N. 53 W.	0.5	N. 53 E.	0.4	S. 82 W.	1.5	N. 53 W.	4.3	N. 47 W.	3.4	N. 18 W.	0.6	W.	0.6	S. 74 W.	2.4	S. 81 W.	2.0	N. 36 W.	1.0	N. 48 W.	1.5
250	S. 76 W.	1.2	N. 63 W.	0.4	N. 65 E.	0.4	S. 83 W.	1.7					N. 26 W.	0.4	S. 69 W.	0.9	S. 68 W.	2.7	S. 80 W.	2.2	N. 55 W.	3.1	N. 64 W.	3.4
500	S. 71 W.	2.0	S. 58 W.	0.9	N. 88 W.	0.4	S. 83 W.	3.3	N. 53 W.	4.8	N. 52 W.	3.6	N. 37 W.	1.0	S. 50 W.	1.7	S. 65 W.	6.3	S. 68 W.	4.0	N. 70 W.	5.3	N. 68 W.	5.2
750	S. 71 W.	2.6	S. 57 W.	2.0	N. 83 W.	0.8	S. 80 W.	4.6	N. 45 W.	6.1	N. 56 W.	4.7	N. 69 W.	1.9	S. 56 W.	2.5	S. 71 W.	8.6	S. 71 W.	5.7	N. 79 W.	6.9	N. 67 W.	6.6
1,000	S. 80 W.	3.8	S. 68 W.	2.9	N. 75 W.	2.4	S. 85 W.	5.9	N. 47 W.	7.1	N. 55 W.	5.5	N. 67 W.	2.6	S. 66 W.	3.6	S. 84 W.	9.2	S. 80 W.	7.0	N. 77 W.	8.2	N. 71 W.	8.0
1,250	N. 87 W.	5.0	S. 86 W.	4.0	S. 86 W.	4.3	S. 86 W.	7.5	N. 49 W.	8.0	N. 57 W.	6.5	N. 72 W.	3.3	S. 74 W.	4.7	S. 83 W.	10.5	S. 86 W.	7.9				
1,500	N. 83 W.	5.7	W.	4.8	N. 85 W.	7.2	S. 89 W.	9.6	N. 52 W.	8.5	N. 59 W.	7.5	N. 84 W.	4.5	S. 78 W.	6.1	N. 89 W.	11.5	N. 89 W.	9.2	N. 72 W.	12.2	N. 69 W.	10.3
2,000	N. 84 W.	7.1	N. 84 W.	6.7	S. 79 W.	12.2	S. 68 W.	13.7	N. 52 W.	11.0	N. 62 W.	9.5	N. 84 W.	6.8	S. 86 W.	7.6	N. 82 W.	13.5	N. 84 W.	11.4	N. 77 W.	15.0	N. 70 W.	12.0
2,500	N. 77 W.	8.2	N. 83 W.	7.7	N. 85 W.	16.2	W.	14.7	N. 47 W.	12.9	N. 62 W.	11.5	S. 87 W.	9.7	S. 86 W.	8.9	N. 79 W.	14.4	N. 84 W.	13.0	N. 75 W.	16.1	N. 73 W.	14.2
3,000	N. 68 W.	9.7	N. 82 W.	9.7	S. 82 W.	14.7	S. 87 W.	16.1	N. 49 W.	13.3	N. 65 W.	12.7	S. 80 W.	12.6	S. 85 W.	10.8	S. 85 W.	16.0	N. 88 W.	13.8	N. 72 W.	15.8	N. 75 W.	15.2
3,500	N. 80 W.	11.4	N. 71 W.	11.0	N. 68 W.	27.1	N. 87 W.	17.3	N. 50 W.	14.6	N. 68 W.	13.0	S. 83 W.	13.6	S. 89 W.	11.5	N. 85 W.	21.6	N. 87 W.	15.8	N. 68 W.	18.7	N. 74 W.	17.0
4,000	N. 87 W.	6.6	N. 73 W.	11.0					N. 45 W.	15.0	N. 68 W.	14.0	N. 65 W.	6.5	N. 88 W.	11.6	N. 68 W.	21.0	S. 87 W.	15.2	N. 64 W.	15.3	N. 77 W.	18.1
4,500	N. 79 W.	8.7	N. 73 W.	11.4																	N. 56 W.	10.5	N. 76 W.	21.2
5,000	N. 55 W.	12.3	N. 81 W.	12.0																	N. 54 W.	8.9	N. 89 W.	16.0

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

February, 1928, was notably free from the more severe weather that frequently prevails during the closing month of winter. Moderately mild temperatures, general absence of severe storms, and little snow cover over large areas afforded unusual opportunity for outdoor occupations.

PRESSURE AND WINDS

Moderate anticyclonic conditions prevailed during much of the month over the Plateau and far Western States, as was the case in January, and no cyclones of importance entered the United States from the Pacific coast during the entire month, a condition rather unusual for February.

Among the more important cyclones of the month over the eastern two-thirds of the country may be mentioned the following:

About the 6th a low-pressure area had moved into the southern Plains region, with center over Oklahoma, attended by light rains over portions of the southern Mountain and Plains States and to some extent in the States to the eastward. By the morning of the 7th the center of low pressure had advanced to Iowa and precipitation had occurred over most of the Mississippi Valley and eastward into the Lake region, Ohio Valley, and Southeastern States. During the following 48 hours the storm area advanced to the Atlantic coast attended by widespread precipitation, mostly rain, but with some snow from the Great Lakes eastward.

Generally clear weather prevailed thereafter until the 13th, when a low-pressure area in the Southwest developed into a general rainstorm central over southwestern Missouri. This storm moved to the southern end of Lake Michigan by the morning of the 14th and precipitation, mostly rain, had extended over much of the country from the Great Plains eastward to the Appalachian Mountains and South Atlantic coast. A secondary storm had developed in the meantime over the Gulf of Mexico and moved to the South Carolina coast. By the following morning the two storms had advanced to New England, attended by widespread precipitation from the Great Lakes and Ohio Valley to the middle and North Atlantic coast.

More or less scattered precipitation occurred on the 16th and 17th from the Rocky Mountains eastward and by the morning of the 18th general cyclonic conditions existed from the Ohio Valley eastward, rather heavy rains occurring over the east Gulf and South Atlantic coasts and general but usually light snows over the Ohio Valley, Lake region, and Northeastern States.

Probably the most important cyclone of the month entered the northwestern section about the 21st, and by the morning of the 22d it was central over Colorado, attended by light snows in the Northern States as far east as the upper Lakes, and by some heavy rains in eastern Texas and portions of near-by areas.

As this storm moved over the Great Plains it separated into two distinct tracks, one moving northeast to the upper Lakes and the other southeast to the lower Mississippi Valley, the precipitation area extending to the Atlantic and Gulf coasts with heavy rains falling over the Southeastern States, and moderate snows in portions of the upper Mississippi Valley, upper Lake region, and New England.

The last half of the third decade was without precipitation over nearly all parts of the country, the last few days, except the 29th, being particularly free from clouds.

The distribution of the average pressure for the month, its departure from the normal, and the change from the preceding month are shown on Charts II, III, and VI.

In the absence of important barometric depressions there were few strong winds and damage to property from these was relatively small. The details concerning wind and other storms during the month are shown in the usual table at the end of this section.

TEMPERATURE

The month was moderately mild throughout, but the first half was distinctly so over much of the country. The first week was warmer than normal save over the extreme Northeastern States, and was decidedly warm over all sections from the Mississippi River westward, the positive departures ranging up to nearly 20°.

The second week was likewise warmer than normal over nearly all districts, the only important sections with negative departures being the Southwest and local small areas along the South Atlantic coast and in the middle plateau. Over the central valleys the week was unusually warm for winter, particularly in the Missouri and upper Mississippi Valleys which had been unduly warm the preceding week also.

The third week continued warm for the season in the upper Missouri Valley, but over most other portions this week was cooler than those preceding, the greatest negative departures, −3° to −9°, occurring in the southern districts.

The closing week, like that preceding, was cool over most portions, small temperature excesses occurring locally in North Dakota and Minnesota, over southern Florida, along the Pacific coast and over portions of the southern plateau. This week was distinctly cool over the upper Missouri and northern Rocky Mountains, where the three preceding weeks had been unusually warm, and it continued distinctly cool over the Central and Southern States east of the Rockies save in southern Florida.

The warmest periods were mainly about the middle of the first decade over the districts from the Great Plains eastward, save in Florida where the highest temperature occurred on the 25th. Over the more western portions a few of the Central States had the warmest days on the 1st to 4th, while in the far Northwest they were about the 9th and 10th or 20th and in the far Southwest about the 27th to 29th.

The lowest temperatures occurred mainly during the last half, about the 14th to 17th over the Southwest; the 18th to 20th over the Southeastern States; and from the 22d to 26th over most other sections.

The highest temperature reported during the month was 94° in Florida on the 25th, but in portions of the Lake region and other northern districts the maximum readings did not reach 60°. The lowest temperature reported was 51° below zero in Wisconsin, at the time of maximum temperature in Florida. This severe cold was confined mainly to a small area in the Lake Superior region, and at points in northern Wisconsin and the adjacent portions of Michigan and Minnesota the temperatures were the lowest ever recorded in February.

The month as a whole was warmer than normal, as was the case during the preceding month, in practically all central and northern districts, and like that month also it was colder than normal in most southern districts except Florida. Over the Missouri and upper Mississippi Valleys and thence northward into Canada the average temperatures ranged from 6° to 15° or more above normal, the excesses increasing to the northward.

PRECIPITATION

As in January there was a widespread deficiency in precipitation as compared with the normal, though the area of deficient fall was less and the departures from the normal were less pronounced, except on the Pacific coast where they were about the same in both months.

Near the South Atlantic and Gulf coasts there were general to moderate excesses, and a considerable area from the southern Rocky Mountains northeast to the upper Mississippi Valley and near-by areas had moderate excesses and there were local excesses in the Middle Atlantic States and southern New England.

SNOWFALL

Snow fell over most areas where it is liable to occur in February, but as in January the amounts were mainly less than the normal for the month. This was particularly the case in the central valleys, over much of New England, and generally in the far western mountains.

The individual snows were mainly light, though rather heavy falls occurred in the Lake region and thence eastward on the 10th and 11th. The distribution of the snowfall is graphically shown on Chart VII.

The total stored snow in the important mountain sections of the West was in many cases less than usually prevails at the end of winter, and the outlook for water for irrigation and power purposes was somewhat discouraging.

RELATIVE HUMIDITY AND SUNSHINE

The percentages of relative humidity were mainly less than normal, with locally large deficiencies in southern California, the upper Missouri Valley, and portions of the middle Gulf States.

Small excesses existed near the Atlantic coast and over most northern districts from the Dakotas eastward, also locally in the southern Plains, the Ohio Valley, and the far Northwest.

Much cloudiness prevailed over the coast districts of Texas and to a less extent over other portions of the Gulf and South Atlantic States, also in the Lake region and far Northwest. Over the Great Plains and mountain regions of the West there was very generally abundant sunshine.

SEVERE LOCAL STORMS, FEBRUARY, 1928

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Iowa (northwest)	4-8					Glaze	Fruit and shade trees injured or destroyed; telephone, telegraph, and electric wires damaged.	Official, U. S. Weather Bureau.
Neal, Kans. (near)	6	1 p. m.				Probably small tornado.	Damage confined to outbuildings and crops.	Do.
Orange, Tex.	7	5 a. m.	2,640		$53,000	Wind and hail	Damage chiefly to oil derricks by wind; roofs and windows damaged by hail.	Do.
Pipestone, Minn.	7-8					Sleet	Extensive damage to trees and overhead wires	Do.

RIVERS AND FLOODS

By R. E. SPENCER

A flood of minor importance occurred during the second week of February in the Wabash and White Rivers of Indiana with resultant losses amounting to $4,450 in suspension of business, and $5,000 in prospective crops. A saving estimated at $10,000 was effected through Weather Bureau warnings.

Aside from the Wabash flood and the prevention of levee repairs by continued high water in the Illinois River, the floods of February were practically without consequence.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE	Feet			Feet	
Cape Fear: Elizabethtown, N. C.	22	25	25	22.6	25
Peedee: Mars Bluff, S. C.	17	25	29	18.4	27
Black: Kingstree, S. C.	12	27	28	12.0	27–28
Santee:					
Rimini, S. C.	12	23	(1)	15.2	27
Ferguson, S. C.	12	24	(1)	13.6	28–29
Altamaha: Charlotte, Ga.	15	25	(1)	16.0	27
MISSISSIPPI DRAINAGE					
Shenango: Sharon, Pa.	9	9	10	10.2	9
Tuscarawas: Gnadenhutten, Ohio	9	9	10	9.8	10
		15	18	11.6	17
Walhonding: Walhonding, Ohio	8	15	16	9.0	15
Wabash:					
Lafayette, Ind.	11	6	7	11.9	6
		15	18	15.4	16
Covington, Ind.	16	16	19	19.5	18
Vincennes, Ind.	14	9	13	14.8	11
Mount Carmel, Ill.	16	8	22	20.7	13
Tippecanoe: Norway, Ind.	6	5	10	6.4	8–9
		14	19	8.5	17–18
		23	23	6.0	23
White: Decker, Ind.	18	10	15	21.9	13
White, East Fork: Seymour, Ind.	10	6	6	10.5	6
		8	8	10.0	8
White, West Fork:					
Elliston, Ind.	19	6	9	22.3	8
Edwardsport, Ind.	15	6	12	18.1	9
		17	19	15.6	18
Illinois:					
Peru, Ill.	14	(2)	(1)	20.0	Dec. 18–19
Henry, Ill.	10	(2)	2	14.4	Dec. 17–18
		9	25	10.8	Feb. 17–19
Havana, Ill.	14	(2)	(1)	18.1	Dec. 19
Beardstown, Ill.	14	(2)	(1)	19.3	Dec. 16–18
Pearl, Ill.	12	7	26	13.7	Feb. 16–17
Grand: Chillicothe, Mo.	18	8	9	18.7	Feb. 8
Black: Corning, Ark.	11	9	13	11.3	Feb. 10–11
		20	21	11.0	Feb. 20–21
		25	(1)	11.7	Feb. 27–28
WEST GULF DRAINAGE					
Trinity:					
Dallas, Tex.	25	23	23	28.0	23
Trinidad, Tex.	28	23	(1)	33.8	27
Guadalupe: Victoria, Tex.	16	26	26	16.4	26

[1] Continued at end of month. [2] Continued from last month.

MEAN LAKE LEVELS DURING FEBRUARY, 1928

By UNITED STATES LAKE SURVEY

[Detroit, Mich., March 3, 1928]

The following data are reported in the Notice to Mariners of the above date:

Data	Lakes [1]			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during February, 1928:	Feet	Feet	Feet	Feet
Above mean sea level at New York	601.88	578.78	571.73	245.99
Above or below—				
Mean stage of January, 1928	−.30	+.06	+.06	−.05
Mean stage of February, 1927	+.55	+.52	+.74	+.68
Average stage for February last 10 years	+.48	−.41	+.61	+.97
Highest recorded February stage	−.60	−3.94	−2.02	−1.68
Lowest recorded February stage	+1.64	+1.36	+1.83	+2.16
Average departure (since 1860) of the February level from the January level	−.20	+.04	−.09	+.07

[1] Lake St. Clair's level: In February, 1928, 573.55 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, FEBRUARY, 1928

By J. B. KINCER

General summary.—Rather widespread rains during the first decade over the Southwest and extending northeastward over the Great Plains and upper Mississippi Valley were very beneficial in relieving droughty conditions, and the additional moisture during the second decade was especially favorable over the area from western Nebraska and eastern Colorado southward. In many other portions of the South good showers occurred, although some Florida uplands continued too dry. The weather was especially favorable in the western Cotton Belt as well as in the Southeast, where truck and other crops were benefited.

During the second decade rather frequent rains in the South Atlantic and East Gulf States from Virginia to the Mississippi River were unfavorable for field operations, while low temperatures retarded growth and did more or less damage to winter truck in southeastern sections. Newly planted crops, particularly potatoes, were unfavorably affected as to germination, while potato tops were frozen in the important producing section of Hastings, Fla. In the Southern States west of the Mississippi River better weather prevailed, with no harmfully low temperatures, and the mostly fair weather permitted much field operations.

During the last decade the widespread, unseasonably cold weather, with considerable precipitation, over the eastern half of the country was generally unfavorable for growth of winter crops and truck in the more southern States, but the low temperatures were favorable in retarding unseasonable advance of fruit buds. Trees were still largely dormant, in marked contrast to last year. Farm work in the South made poor progress and further cold and the absence of snow were again rather unfavorable in the interior and Middle Atlantic States; seasonal farm work made little progress. Conditions were generally favorable in many of the Western States during most of the month, except that toward its close there was some suffering of livestock reported from the northern Rocky Mountain area and rain was needed in much of California.

Small grains.—Winter wheat was favored by the widespread moisture during the first decade in the theretofore droughty areas, especially in the central and west-central Great Plains. In the Ohio Valley, however, conditions were less favorable, with the ground mostly bare of snow and many reports of apparent damage to wheat by heaving. Further complaints were also noted in parts of the middle Atlantic area, particularly in Pennsylvania, but in the more Western and Northwestern States conditions were generally favorable. A rather extensive snowstorm the latter part of the second decade gave wheat fields a fair covering and protection in the northeastern Ohio Valley, parts of the Middle Atlantic States and the Lake region, but in other portions of the Wheat Belt fields continued mostly bare. There was distinct improvement in Kansas, western Oklahoma, and in Texas, although growth was slow in the latter State because of cold.

During the last decade only a few localities in the northern Ohio Valley were afforded protection during the cold weather, and this made a continuation of rather unfavorable conditions for wheat in the eastern half of the belt, with further reports of injury. In most of the western belt conditions remained mostly favorable, though growth was slow in southern districts because of cold weather. In the far Northwest favorable condi-

tions continued, except for some thawing and freezing, but more moisture was needed in California, parts of the far Southwest, and some Rocky Mountain districts.

Miscellaneous.—Pastures continued mostly in poor condition in the Southeast during the first decade and reports of rather extensive injury to grass and clover were noted from many central sections. The mild weather during this period permitted free ranging of livestock in the northern Great Plains and the range was mostly open in Wyoming. Moisture was insufficient in parts of the central Rocky Mountain region and additional precipitation was needed in some other western areas. Livestock continued to do well generally. During the second decade conditions remained practically unchanged in the Southeast and central sections, but general snow in New Mexico was of benefit. Lambing was progressing satisfactorily in Wyoming, with shearing begun in Arizona. Continued freezing and thawing caused some injury in central sections during the last decade, but there was slight improvement in the Southeast and reports were mostly favorable in the great western grazing districts.

Continued dry weather was unfavorable for recovery of damaged truck in Florida during the first part of the month, but planting and replanting were active. Truck crops continued poor during the second decade with rainfall needed on Florida uplands, while frost and freezing weather on the 19th and 20th in the northern part of this State cut potatoes to the ground in the Hastings district and damaged truck and melons elsewhere. Winter and spring truck crops made mostly slow growth in the Southern States during the last part of the month, though showers were beneficial locally. The cool weather most of the month was favorable in retarding the unseasonable advance of fruit buds, and trees were largely dormant at the close. Citrus bloom escaped serious injury by the cold weather in Florida and much bloom and new growth were noted at the close of the month.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

February is normally one of the stormiest months of the year over the North Atlantic, and while during the current month the number of days with gales was not far from the normal over the greater part of the ocean, a large number of casualties was reported, not only at sea but also on the European coast.

During the first two decades of the month both the North Atlantic HIGH and Icelandic LOW were, for the most part, unusually well developed, while the last decade was characterized by sudden changes of pressure in the vicinity of the Azores and anticyclonic conditions over northern Europe.

One unusual feature was the comparatively high force of the northeast trades during both the first and last periods of the month, which will be referred to later.

The number of days with fog was apparently considerably below normal over the entire ocean, except along the American coast between Hatteras and Nantucket and also in the Gulf of Mexico, being reported on five days in both these localities.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (75th meridian), North Atlantic Ocean, February, 1928*

	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Belle Isle, Newfoundland	29.68	−0.07	30.42	23d	29.18	25th.[2]
Halifax, Nova Scotia	30.01	+0.03	30.62	22d	29.44	19th.
Nantucket	30.06	0.00	30.66	3d	29.36	18th.
Hatteras	30.15	+0.02	30.52	22d	29.48	18th.
Key West	30.10	+0.02	30.32	19th	29.96	16th.
New Orleans	30.17	+0.07	30.50	19th	29.86	13th.[2]
Cape Gracias, Honduras	29.95	−0.02	30.62	19th [2]	29.88	23d.
Turks Island	30.16	+0.08	30.22	20th [2]	30.10	1st.[2]
Bermuda	30.21	+0.07	30.52	22d	29.80	29th.
Horta, Azores	30.13	+0.12	30.60	3d	29.68	27th.
Lerwick, Shetland Islands	29.65	−0.07	30.54	23d	28.64	1st.
Valencia, Ireland	29.99	+0.09	30.59	22d	29.48	10th.[2]
London	30.10	+0.10	30.57	20th	29.26	11th.

[1] From normals shown on H. O. Pilot Chart, based on observations at Greenwich mean noon or 7 a. m. 75th meridian.
[2] And on other dates.

On the 1st and 2d a LOW was central off the north coast of Scotland and moderate to strong northerly to westerly gales prevailed between the 30th meridian and the European coast. From the 3d to the 5th the greater part of the steamer lanes was storm swept, and on the latter date Belle Isle was also near the center of a violent disturbance of limited extent.

From the 5th to 9th the northeast trades were unusually strong, as shown by the report from the Danish M. S. *California*, in table of gales and storms.

From the 6th to 9th westerly gales still prevailed over the middle and eastern sections of the ocean and on the 8th and 9th a fairly well developed cyclonic disturbance was central near 30° N., 45° W., with strong gales near the center. This disturbance moved slowly eastward, and on the 11th a southeast gale was encountered near 25° N., 43° W., as shown by report in table from the Dutch S. S. *Hector*.

On the 11th and 12th winds of hurricane force swept over the northern steamer lanes between the 30th meridian and European coast and considerable damage to shipping was reported, as well as on shore.

On the 13th and 14th a severe disturbance was over the area between the 30th and 50th parallels and the 30th and 65th meridians that reached its greatest intensity on the latter date. On the 15th land stations on the British Isles reported southwest winds of force 7 to 9.

Charts VIII to XI cover the period from the 17th to 20th, inclusive.

On the 22d and 23d a disturbance was over the middle sections of the steamer lanes that by the 24th had increased both in extent and intensity, as on that date it covered the greater part of the region between the Azores and the 50th meridian.

From the 23d to 28th the northeast trades, for the second time during the month, were unusually strong, as shown by report in table from the American S. S. *Atlantic*.

On the 25th and 26th a depression was central near the Azores that moved slowly northeastward and by the end of the month was over the British Isles.

On the 27th gales were reported by a number of vessels in mid-ocean; the storm area increased in extent and by the 28th extended from the 10th to the 40th meridians.

On the 29th a well-developed LOW of limited extent was central about 250 miles east of Bermuda, as shown by report from the American S. S. *Western Ally*.

OCEAN GALES AND STORMS, FEBRUARY, 1928

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Karlsruhe, Ger. S. S.	Bremen	New York	48 52 N.	31 27 W.	Feb. 2	—, 3	Feb. 4	29.84	SW	W., 9	NW	W., 11	
Boston City, Br. S. S.	Bristol	Philadelphia	47 30 N.	36 20 W.	2	Noon, 3	4	29.85	SW	WNW., 9	NW	NW., 10	SW.-NW.
United States, Dan. S. S.	Halifax	Christiansand	55 45 N.	27 45 W.	2	4 a., 4	6	29.15	S	WSW., 10	W	WSW., 10	S.-WSW.
California, Dan. S. S.	Bahia, Brazil	Copenhagen	13 23 N.	25 08 W.	5	2p., 5	9	29.89	ENE	ENE., 5	ENE	ENE., 8	Steady.
Karlsruhe, Ger. S. S.	Bremen	New York	46 19 N.	41 08 W.	5	—, 5	6	29.80	WSW	SW., 10	N	SW., 11	
Atlanta City, Am. S. S.	Gibraltar	do	33 11 N.	45 41 W.	7	4 a., 8	9	29.96	NE	NE., 9	NE	NE., 10	Steady.
City of Flint, Am. S. S.	Dundee	Philadelphia	54 23 N.	29 00 W.	9	10 a., 9	9	29.35	W	W	W	W., 10	Do.
Hector, Ger. S. S.	Amsterdam	Venezuela	26 07 N.	41 16 W.	9	7 p., 10	12	29.93	SE	SE., 8	SSE	SE., 9	
Bellflower, Am. S. S.	Manchester	New York	55 14 N.	14 17 W.	10	2 p., 10	11	28.49	WSW	WSW., 12	WNW	—, 12	WSW.-NW.
Delilian, Br. S. S.	Cuba	Liverpool	51 37 N.	5 05 W.	10	10 p., 10	11	28.77	SW	W., 12	W	W., 12	SW.-W.
Amsterdam, Du. S. S.	Baton Rouge	Amsterdam	38 37 N.	61 53 W.	12	Noon, 12	14	29.59	N	N., 6	N	NNW., 10	N.-NNW.
Oklahoma, Fr. S. S.	Havre	New York	36 39 N.	44 23 W.	12	9 p., 13	14	29.49	S	SW., 11	WNW	—, 12	
Hamburg, Ger. S. S.	English Channel.	do	49 01 N.	26 41 W.	14	8 p., 14	14	29.34	SW	SW., 10	WSW	—, 11	SW.-WSW.
Stadsdijk, Du. S. S.	Algiers	Boston	43 07 N.	48 55 W.	16	11 a., 17	18	28.77	W	SSE	WNW	WNW., 12	
J. A. Bostwick, Am. S. S.	Cartagena	Charleston	28 30 N.	77 29 W.	18	6 a., 18	19	29.95	SSW	SSW	NNW	NW., 9	W.-NW.
City of Eureka, Am. S. S.	Morocco	New York	34 50 N.	65 27 W.	18	3 a., 19	21	29.56	SSW	SSW., 11	NW	SSW., 11	SSW.-W.-NW.
Eurana, Am. S. S.	Canal Zone	London	41 10 N.	42 48 W.	19	2 a., 20	20	29.50	SW	WSW., 5	NW	—, 11	SW.-WNW.
Idaho, Br. S. S.	Newcastle	Boston	53 00 N.	33 00 W.	21	5 p., 21	22	29.58	SW	SW., 9	W	W., 10	SW.-W.
Oklahoma, Fr. S. S.	Havre	New York	38 30 N.	69 42 W.	23	—, 23	23	29.68	SSE	SSE		—, 12	SSE.-SE.
Atlantic, Am. S. S.	Rio de Janeiro	Baltimore	4 30 N.	40 58 W.	23	4 p., 24	28	29.87	NE	NE., 9	ENE	ENE., 9	NE.-ENE.
Galtymore, Br. S. S.	Liverpool	Boston	51 10 N.	31 33 W.	24	4 a., 24	25	29.48	N	N., 11	NNE	N., 12	Steady.
Bolivier, Belg. S. S.	New York	Antwerp	46 00 N.	28 00 W.	23	10 p., 24	25	28.99	NNW	NNW	N	NNW., 12	
Sac City, Am. S. S.	Antwerp	Boston	47 00 N.	39 00 W.	25	6 p., 26	27	29.47	SW	WNW., 6	WNW	NW., 10	SW.-NW.
Cripple Creek, Am. S. S.	Glasgow	Galveston	43 30 N.	24 25 W.	27	4 p., 27	29	29.12	W	W., 8	WNW	WNW., 10	W.-WNW.
Sac City, Am. S. S.	Antwerp	Boston	44 10 N.	46 48 W.	28	6 p., 28	29	29.52	SW	W., 8	NW	WNW., 12	SW.-WNW.
Western Ally, Am. S. S.	Rotterdam	New York	33 50 N.	60 25 W.	29	6 a., 29	29	29.52	S	SW., 9	NW	NW., 9	SW.-NW.
Mercier, Belg. S. S.	New York	Antwerp	46 52 N.	31 12 W.	29	Noon, 29	29	29.16	NNE	NNE., 7	NNW	NNW., 11	
Bellepline, Am. S. S.	Rotterdam	New York	44 51 N.	19 47 W.	29	8 p., 29	Mar. 1	29.34	SSW	SSE., 10	WNW	WNW., 11	WSW.-WNW.
NORTH PACIFIC OCEAN													
West Hixton, Am. S. S.	Astoria	Nagoya	51 23 N.	178 34 W.	Feb. 1		Feb. 3	28.52	WSW	NNW., 7	WNW	NW., 10	SW.-NW.
West Chopaka, Am. S. S.	San Francisco.	Yokohama	48 17 N.	173 40 W.	1	2p, 4	4	28.76	S	WSW., 10	N	W., 11	WSW.-W.
Oridono Maru, Jap. S. S.	Muroran	Coos Bay	49 50 N.	168 15 W.	2	5a., 3	4	28.12	SSW	WSW., 9	W	—, 11	SW.-W.
Emp. of Asia, Can. S. S.	Yokohama	Vancouver	41 23 N.	153 20E.	4	Noon, 5	6	29 13	ENE	ENE., 9	N	N., 9	ENE.-N.
Toyama Maru, Jap. S. S.	do	Victoria	49 20 N.	142 20 W.	5	4 a., 6	6	28.49	NE	NE., 6	SW	SW., 9	14 pts.
Grace Dollar, Am. S. S.	Manila	San Francisco.	38 18 N.	141 00 W.	5	8 a., 5	6	29.95	S	S., 8	S	S., 10	Steady.
Emp. of Russia, Br. S. S.	Victoria	Yokohama	51 03 N.	137 14 W.	6	2 p., 6	6	29.13	SE	SSW., 10	WSW	SSW., 10	S.-SSW.
Shabonee, Br. S. S.	Nagasaki	San Pedro	33 02 N.	135 30 E.	6	Noon., 6	6	29.64	ESE	E., 9	ENE	E., 9	E.-NE.
West Islip, Am. S. S.	Otaru	San Francisco.	47 18 N.	178 55 E.	8	8 p., 8	9	29.46	SSE	SE., 10	W	SE., 11	SE.-SW.
West Hixton, Am. S. S.	Astoria	Nagoya	46 40 N.	163 30 E.	8	2 a., 8	9	28.86	SE	SE., 10	W	SW., 10	WSW.-SSW.
Juyo Maru, Jap. S. S.	Muroran	Vancouver	48 50 N.	179 22 E.	8	8 p., 9	9	29.47	SSE	SE	WSW	SE., 11	
West O'Rowa, Am. S. S.	China	Portland	51 35 N.	166 40 W.	8	2 a., 10	10	29.30	SE	W., 4	W	SE., 10	SE.-W.
West Henshaw, Am. S. S.	Hong Kong	San Francisco.	35 25 N.	156 00 E.	11	7 a., 12	14	29.47	SW	SW., 10	NW	SW., 10	SW.-NW.
West Islip, Am. S. S.	Otaru	do	47 53 N.	163 50 W.	10	8 p., 11	15	29.81	W	SW., 10	S	SSW., 11	SW.-WSW.
Juyo Maru, Jap. S. S.	Muroran	Vancouver	49 48 N.	156 03 W.	12	8 p., 13	17	29.81	S	S	SE	S., 10	Steady.
West Chopaka, Am. S. S.	San Francisco	Yokohama	36 40 N.	142 30 E.	14	6 a., 15	15	29.04	SE	W., 8	NE	SE., 10	SE.-SW.-W.
West Hixton, Am. S. S.	Astoria	Nagoya	38 12 N.	142 15 E.	14	6 a., 15	15	29.44	ESE	N., 10	NNE	N., 10	E.-N.-NE.
Manoa, Am. S. S.	Honolulu	San Francisco.	36 55 N.	125 13 W.	14	10 p., 15	15	30.20	NNW.	NNW., 9	NNW.	NNW., 9	Steady.
Shabonee, Br. S. S.	Nagasaki	San Pedro	40 06 N.	174 18 E.	16	Midt., 16	17	29.15	SE	SSE., 10	S	SSE., 10	SSE.-SSW.
West Henshaw, Am. S.	Hong Kong	San Francisco.	37 02 N.	174 40 E.	16		18	29.36	S			SW., 12	
Bengal Maru, Jap. S. S.	Yokohama	do	40 06 N.	166 43 E.	15	Mdt., 16	19	28.65	SE	WSW., 9	WNW	W., 11	
Kaga Maru, Jap. S. S.	do	Victoria	49 30 N.	168 17 W.	16	8 a., 17	18	29.54	SSE	SE	SSE	SE., 9	
Volunteer, Am. S. S.	San Pedro	Yokohama	30 36 N.	162 25 E.	18	11p ., 18	18	29.81	WNW	WNW., 8	WNW	W., 9	SW.-WNW.
San Mateo, Am. S. S.	San Francisco.	Cristobal	13 47 N.	94 32 W.	18	4 p., 18	19	29.89	NW	NNE., 8	NE	NE., 10	NW.-N.-NNE.
Shabonee, Br. S. S.	Nagasaki	San Pedro	40 00 N.	156 15 W.	21	4 a., 22	22	29.23	SE	SSE., 8	SW	SE., 9	SE.-S.-SW.
Pres. Jefferson, Am. S. S.	Seattle	Yokohama	46 16 N.	159 10 E.	22	Noon, 22	22	29.22	W	W., 8		W., 9	
Volunteer, Am. S. S.	San Pedro	do	33 09 N.	143 26 E.	23	2 a., 24	26	29.43	WSW	WSW., 11	NW	WSW., 11	WSW.-W.
West Niger, Am. S. S.	Yokohama	Portland	42 53 N.	155 30 W.	24	9 p., 24	25	28.82	E	NE., 9	N	NE., 9	E.-NE.-N.
Shabonee, Br. S. S.	Nagasaki	San Pedro	38 30 N.	138 00 W.	25	2 p., 25	25	29.64	E	SE., 7	SE	E., 9	E.-SE.
Levant Arrow, Am. S. S.	Woosung	do	40 37 N.	162 00 E.	24	8 a., 25	26	28.71	SSW	WSW., 9	NW	NNW., 11	WSW.-NW.
Do	do	do	40 39 N.	172 52 E.	27	4 p., 27	27	29.06	SW	WSW., 10	NW	WNW., 11	
Silveray, Br. M. S.	Calcutta	San Francisco.	34 54 N.	160 25 E.	25	Noon, 25	26	29.70	WSW	W., 11	W	W., 12	WSW.-WNW.
Lebec, Am. S. S.	San Pedro	Balboa	15 15 N.	94 32 W.	25	2 a., 26	26	29.96	NE	N., 9	NW	N., 9	NE.-N.-NW.
West Henshaw, Am. S. S.	Hong Kong	San Francisco.	39 40 N.	145 00 W.	26	4 a., 26	26	29.72	NE	N., 12	N	N., 12	Steady.
Emp. of Canada, Br. S. S.	Yokohama	Vancouver	50 02 N.	171 00 W.	28	10 p., 28	29	28.84	SSW	SSW., 9	SW	SSW., 9	SSW.-S.-WSW.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

February, 1928, was the third stormy month of the season on the North Pacific Ocean, the others being November and December. January, while rough, had fewer gales exceeding force 10 than any of the other three. In February gales of various strengths were frequent over all the middle and northern parts of the ocean, but wind velocities of force 11 to 12 were reported on at least nine days, these occurring principally within the boundaries of the thirtieth and fiftieth parallels, and longitudes 160° W. to 150° E. In this general region the heaviest weather was experienced south of the Aleutian Islands on the 3d, 9th, and 11th, and between the thirtieth and forty-fifth parallels, west of the one hundred and eightieth meridian, on the 16th and 17th and from the 24th to the 28th. The northernmost gales were due to intensifications of the Aleutian LOW; the others to strong progressive cyclones coming from Asiatic sources. Most of the far eastern cyclones of the month entered the ocean in middle to higher latitudes, and as they moved outward, in addition to other gales, caused local increases in the intensity of the northeast monsoon to gale force from Japan southward to Luzon. The monsoon, however, was fresh to strong almost throughout February, pressure being high off the China coast, and barometric gradients sharp to the eastward and northeastward. The moderate cyclone mentioned last nonth as laying off the California coast at the end of January, went inland near San Francisco on February 4, and after crossing the United States, entered the North Atlantic Ocean on the 9th.

The Aleutian cyclone, as in January, was central in the neighborhood of Dutch Harbor, and abnormally deep, the average lowest pressure being 29.30 inches, or about a third of an inch under the average for a period of years. Thence eastward toward the lower Alaskan coast pressure as a whole rose rapidly, being 29.63 inches midway, at Kodiak, and 30.06 at Juneau. The North Pacific anticyclone was generally well developed, with average pressures mostly above the normal along lower middle latitudes from California nearly to Midway Island, and up along the American coast to and beyond Juneau.

Table of pressure data for several island and coast stations in west longitudes follows:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, February, 1928*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1]	29.30	−0.32	30.29	9th [4]	28.50	24th.
St. Paul [1]	29.39	−0.27	30.32	8th	28.64	21st. [4]
Kodiak [1]	29.63	−0.07	30.40	17th	28.84	5th.
Midway Island [1]	30.02	−0.01	30.26	8th [4]	29.76	28th. [4]
Honolulu [3]	30.07	+0.03	30.18	25th	29.92	14th.
Juneau [2]	30.06	+0.14	30.64	16th	29.28	4th.
Tatoosh Island [2] [3]	30.18	+0.20	30.55	8th	29.42	3d.
San Francisco [2] [3]	30.13	+0.06	30.47	6th	29.52	3d.
San Diego [2] [3]	30.07	+0.03	30.35	8th	29.75	2d.

[1] P. m. observations only.
[2] A. m. and p. m. observations.
[3] Corrected to 24-hour mean.
[4] And other dates.

The prevailing wind direction at Honolulu was from the east, with the maximum velocity at the rate of 24 miles an hour from the east, on the 1st. Unusually warm weather continued to prevail off the coast of southeastern Alaska. At Juneau this was the third warmest February of record.

Moderate to severe northers, although not so frequent as in the preceding month, occurred on several days in the Gulf of Tehuantepec.

There was comparatively little fog on the ocean, as is usual in February. Isolated instances of its formation were reported from the Aleutians eastward and southeastward, with the place of maximum occurrence west of the central California coast, where there were at least seven days with it. Fog was reported on four days west of Lower California, and also on four days in the Gulf of Tehuantepec.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation of sections, February, 1928

Section	Temperature							Precipitation					
			Monthly extremes							Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		Ins.	In.		In.		In.
Alabama	48.2	−0.1	Spring Hill	83	5	2 stations	11	19	3.79	−1.51	Seven Hills	9.27	Tuscumbia	1.39
Arizona	46.9	−1.0	2 stations	85	[1]27	Snowflake	−12	17	1.69	+0.57	Canille	5.21	Wellton	0.03
Arkansas	45.0	+2.2	Subiaco	79	5	2 stations	10	[1]17	2.23	−1.12	Texarkana	4.69	Gilbert	0.90
California	48.8	+0.5	2 stations	86	[1]1	Helm Creek	−14	[1]5	2.44	−1.76	West Branch	8.34	Haiwee	0.00
Colorado	27.4	+0.8	Holly	74	4	Hermit	−27	14	0.79	−0.33	Savage Basin	3.72	Fruita	T.
Florida	61.9	+1.8	Lake Alfred	94	25	2 stations	20	10	3.06	−0.11	Metts	9.95	Everglades	0.09
Georgia	48.9	+0.9	2 stations	82	[1]4	Clayton	7	19	5.10	+0.10	Brooklet	10.02	Atlanta	2.50
Idaho	27.5	−0.7	Mullan	57	20	Big Springs	−30	24	0.47	−1.33	Tripod Mountain	1.80	Gooding	0.02
Illinois	33.6	+5.1	Cairo	67	6	Freeport	−4	25	2.18	+0.23	Newton	5.88	Rockford	0.81
Indiana	32.0	+2.4	Rome	65	4	2 stations	−3	[1]10	2.79	+0.25	Columbus	4.74	Greenfield	0.81
Iowa	28.6	+6.0	Bonaparte	65	3	Postville	−14	25	1.95	+0.75	Lacona	3.97	West Bend	0.62
Kansas	36.8	+4.4	Richfield	78	4	Tribune	1	25	1.87	+0.74	Garnett	4.02	Saint Francis	0.14
Kentucky	38.1	+2.1	Williamsburg	72	4	2 stations	5	26	2.47	−1.06	Murray	4.16	Whitesburg	0.88
Louisiana	52.9	−0.3	Lake Arthur	82	7	Tallulah	19	19	4.90	+0.41	Burrwood	10.94	Calhoun	1.95
Maryland-Delaware	35.5	+2.5	2 stations	66	4	Oakland, Md	0	22	2.83	−0.21	Wilmington, Del	4.45	Picardy, Md	1.43
Michigan	22.4	+3.1	2 stations	52	[1]5	Humboldt	−48	25	1.58	−0.10	Wellston (near)	3.62	Humboldt	0.42
Minnesota	18.0	+6.5	Worthington	55	3	3 stations	−27	[1]18	0.67	−0.05	Grand Meadow	1.99	2 stations	0.00
Mississippi	49.3	0.0	2 stations	79	[1]6	Pontotoc	16	19	3.13	−1.79	Bay Saint Louis	10.97	Hernando	1.25
Missouri	37.0	+5.2	Poplar Bluff	71	11	Lamonte	−2	24	2.28	+0.13	Centerview	4.10	Fulton	1.03
Montana	24.1	+2.8	Darby	65	20	2 stations	−30	[1]23	0.30	−0.48	Crow Agency	1.16	3 stations	T.
Nebraska	30.8	+5.7	Madrid	72	4	Gordon	−13	23	0.95	+0.23	Pawnee City	3.56	Madrid	T.
Nevada	36.0	+0.7	Searchlight	73	[1]28	Owyhee	−6	15	0.33	−0.63	Sharp	1.22	Beowawe	0.00
New England	22.7	+0.3	Chestnut Hill, Mass.	59	5	Van Buren, Me	−37	22	3.02	−0.22	Norwalk, Conn	5.50	Presque Isle, Me	1.08
New Jersey	32.1	+2.4	2 stations	63	23	Layton	−6	22	4.05	+0.30	Chatham	5.63	Phillipsburg	2.17
New Mexico	35.7	−2.0	Artesia	81	28	Luna Ranger Station	−20	15	1.12	+0.46	Kingston	3.75	Ione	T.
New York	42.8	+0.7	Goldsboro	76	4	Mount Mitchell	−6	18	3.93	−0.33	Southport	8.39	Asheville	0.96
North Carolina	18.8	+10.9	Hettinger	59	11	McLeod	−19	24	0.10	−0.39	McLeod	0.51	11 stations	0.00
North Dakota	31.2	+2.1	Ironton	67	4	Wauseon	−8	26	2.83	+0.48	Dover	4.72	Catawba Island	1.08
Ohio	44.0	+2.6	Frederick	83	5	Hooker	2	25	1.90	+0.62	Smithville	3.72	Boise City	0.44
Oklahoma	37.7	+0.4	Marshfield	72	9	Ukiah	−8	15	1.52	−2.28	Government Camp	6.62	Hermiston	0.14
Oregon	30.3	+2.6	2 stations	65	[1]4	Bradford	−11	26	3.42	+0.76	Creekside	5.39	Erie	1.62
Pennsylvania	46.2	−1.2	2 stations	75	4	Walhalla	13	19	5.05	+0.72	Beaufort (near)	9.51	Due West	2.65
South Carolina	25.6	+7.4	Hermosa	72	11	Cottonwood	−16	23	0.56	−0.01	Centerville	2.97	4 stations	0.00
South Dakota	41.7	+0.8	2 stations	75	6	Crossville	−2	19	2.22	−2.11	Dresden	5.12	Buffalo Valley	0.86
Tennessee	51.2	+0.7	Presidio	90	29	2 stations	3	[1]17	2.62	+0.76	San Marcos	6.66	2 stations	0.00
Texas	31.7	−1.6	Saint George	70	2	Duchesne	−19	16	0.76	−0.47	Kanosh	2.93	4 stations	T.
Utah	38.7	+1.7	Hopewell	70	4	Burkes	7	19	2.26	−0.87	Wallaceton	3.79	Wytheville	0.89
Virginia	35.7	+1.5	2 stations	65	10	3 stations	−4	[1]23	1.25	−2.76	Cougar	9.27	Rock Island	0.01
Washington	34.6	+2.3	Williamson	72	4	Bayard	−3	19	2.50	−0.54	Pickens	6.06	Upper Tract	0.40
West Virginia	20.4	+4.7	Milwaukee County Airport.	58	4	Rest Lake	−51	25	1.56	+0.40	Brillion	3.95	Cornucopia	0.13
Wisconsin	21.7	−0.3	2 stations	66	11	Moran	−43	25	0.65	−0.10	Elk Mountain	2.80	Spencer (near)	T.
Wyoming	68.5	0.0	2 stations	88	[1]23	Kaililili	42	26	4.01	−2.28	Olokele (mauka)	16.20	3 stations	0.00
Hawaii	73.4	−0.1	Santa Rita	95	28	Toro	50	12	1.83	−0.95	Cabo Rojo	8.22	Santa Rita	0.00
Porto Rico														
Late reports, January, 1928:														
Alaska	10.6	+2.0	Ketchikan	52	16	Allakaket	−50	18	2.84	+0.72	Latouche	21.26	Fort Yukon	0.12
New York	25.5	+3.0	Dansville	58	15	Stillwater Reservoir	−28	27	2.41	−0.54	Stillwater Reservoir	6.48	Avon	0.55
Porto Rico	73.6	+0.4	Santa Rita	95	2	2 stations	52	2	2.25	−1.47	San German	8.93	2 stations	0.00

[1] For description of tables and charts, see REVIEW, January, 1928, p. 29.

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, February, 1928*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Stations, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind (3-cup anemometer used): Total movement	Wind (3-cup anemometer used): Prevailing direction	Wind (3-cup anemometer used): Maximum velocity: Miles per hour	Wind (3-cup anemometer used): Maximum velocity: Direction	Wind (3-cup anemometer used): Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
New England	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								0–10	*In.*	*In.*
							26.3	+0.9										72	3.14	−0.2											5.4		
Eastport	76	67	85	29.89	29.99	0.00	21.7	+0.2	46	23	31	−8	26	13	35	20	13	71	1.59	−1.9	14	7,779	w.	42	e.	15	8	6	15	6.3	9.3	0.3
Greenville, Me	1,070	6	----	28.77	29.99	------	13.6	------	39	4	25	−17	26	2	42	----	----	----	1.09	------	10	------	nw.	------	------	----	14	3	12	----	14.1	----
Portland, Me	103	82	117	29.92	30.04	+.02	24.6	+0.8	49	4	33	−5	26	17	34	21	15	68	3.94	−0.2	11	6,151	n.	30	se.	15	15	5	9	4.4	10.8	T.
Concord	289	70	79	29.71	30.04	.00	23.0	+0.2	53	4	33	−7	26	13	36	----	----	----	2.50	−0.5	12	4,073	nw.	26	w.	20	16	4	9	4.2	8.8	0.1
Burlington	403	11	48	29.58	30.05	+.02	19.8	+0.4	44	23	28	−8	26	12	29	----	----	----	1.52	−0.1	14	7,333	s.	38	s.	22	7	8	14	6.8	7.6	0.5
Northfield	876	12	60	29.05	30.04	.00	17.7	+1.3	47	24	28	−17	26	7	37	16	12	80	1.57	−0.8	12	4,768	n.	26	sw.	20	9	4	16	6.5	10.8	5.3
Boston	125	115	188	29.90	30.04	.00	29.6	+0.8	54	4	38	−1	26	21	36	26	18	64	2.66	−0.8	9	6,781	sw.	26	e.	15	9	12	8	4.9	8.7	0.0
Nantucket	12	14	90	30.02	30.03	−.01	31.2	+0.5	49	8	38	10	26	25	26	29	25	79	4.81	+1.6	13	10,372	w.	42	se.	23	10	8	11	5.9	2.6	0.0
Block Island	26	11	46	30.01	30.04	−.02	32.0	+1.6	53	23	38	6	26	26	22	29	25	76	4.15	+0.4	11	12,238	w.	56	w.	20	9	10	10	5.4	4.7	0.0
Providence	160	215	251	29.87	30.06	−.01	29.3	+0.3	54	4	37	0	26	21	32	26	19	65	2.85	−0.9	10	7,769	nw.	44	se.	23	11	10	8	4.9	5.5	0.0
Hartford	159	122	----	29.88	30.06	.00	29.2	+2.0	55	4	37	0	26	21	28	----	----	----	4.04	0.0	9	------	sw.	------	------	----	13	7	9	4.7	7.3	0.0
New Haven	106	74	153	29.96	30.06	+.01	31.0	+2.0	57	23	39	2	26	23	26	28	23	74	4.90	+0.7	11	6,156	sw.	31	se.	14	12	8	9	4.9	0.0	0.0
Middle Atlantic States																																
							35.0	+1.6										71	2.78	−0.3											5.7		
Albany	97	102	113	29.96	30.06	+.01	26.6	+2.5	51	4	35	−3	26	18	31	24	19	76	2.55	0.0	11	4,962	s.	23	s.	3	11	6	12	5.3	6.5	T.
Binghamton	871	10	84	29.09	30.06	−.02	27.1	+3.1	54	4	36	0	26	19	35	----	----	----	2.68	+0.7	15	4,523	w.	21	w.	20	6	6	17	6.8	6.4	0.0
New York	314	414	454	29.73	30.09	+.01	32.9	+1.6	55	23	40	6	26	25	22	29	22	64	4.35	+0.5	11	11,575	nw.	49	se.	14	9	9	11	5.8	4.0	0.0
Harrisburg	374	94	104	29.70	30.12	+.03	32.5	+2.3	59	4	40	11	26	25	33	28	22	68	3.46	+0.6	13	4,795	w.	27	w.	20	5	10	14	6.7	2.0	0.0
Philadelphia	114	123	182	29.98	30.12	+.02	35.1	+1.2	59	23	42	11	26	28	25	32	26	70	4.00	+0.6	10	7,277	sw.	35	nw.	20	10	6	13	5.8	1.0	0.0
Reading	325	81	98	29.74	30.10	------	32.4	------	56	29	40	9	26	25	30	30	26	76	4.30	+0.7	14	4,607	w.	22	nw.	24	11	7	11	5.4	5.5	0.0
Scranton	805	111	119	29.19	30.08	.00	28.8	+1.5	52	4	37	3	26	20	30	26	22	79	2.16	−0.7	11	4,971	s.	23	s.	20	9	7	13	6.0	9.4	T.
Atlantic City	52	37	172	30.04	30.10	−.01	35.8	+2.2	62	23	43	11	26	29	24	33	30	80	2.72	−0.8	9	11,028	nw.	80	se.	23	10	11	8	4.9	1.2	0.0
Cape May	17	13	49	----	----	------	35.8	+1.7	62	23	43	12	26	28	25	33	29	80	2.30	------	8	------	nw.	------	------	----	9	10	10	----	0.1	0.0
Sandy Hook	22	10	55	30.06	30.06	------	32.6	------	50	4	38	9	26	27	21	29	23	68	4.71	------	9	10,246	w.	46	w.	20	11	6	12	5.4	2.7	0.0
Trenton	190	159	182	29.88	30.09	------	32.5	------	56	23	41	7	26	24	26	29	24	71	4.09	+0.8	9	7,098	nw.	37	nw.	20	9	7	13	6.2	2.7	0.0
Baltimore	123	100	215	29.98	30.11	.00	37.6	+2.2	63	4	45	16	26	30	31	32	28	66	2.89	−0.6	10	6,698	sw.	37	w.	20	10	6	13	5.8	0.1	0.0
Washington	112	62	85	29.99	30.12	+.01	37.6	+2.3	63	4	46	17	26	30	35	32	24	63	2.69	−0.5	10	4,674	nw.	30	nw.	19	8	10	11	5.7	T.	0.0
Cape Henry	18	8	54	30.08	30.10	------	43.4	------	67	4	50	23	26	30	39	34	34	73	3.31	0.0	12	7,951	sw.	35	nw.	12	11	6	12	5.3	1.0	0.0
Lynchburg	681	153	188	29.37	30.14	+.03	40.6	+0.3	68	4	50	20	19	31	37	34	26	62	2.40	−0.9	8	5,033	w.	35	nw.	19	8	12	9	5.4	0.3	0.0
Norfolk	91	170	205	30.04	30.14	+.03	43.6	+0.9	65	4	52	25	26	36	29	39	33	72	2.85	−0.5	13	8,469	ne.	41	w.	18	13	3	13	5.2	1.7	0.0
Richmond	144	11	52	29.98	30.14	+.03	40.4	+0.8	66	4	50	21	26	31	34	35	30	72	1.84	−1.4	10	5,071	sw.	35	w.	20	13	5	11	4.9	1.8	0.0
Wytheville	2,304	49	55	27.67	30.13	+.01	35.4	+0.3	59	4	44	12	19	27	32	30	25	72	0.89	−3.3	10	5,100	w.	26	nw.	20	9	5	15	5.9	2.0	0.0
South Atlantic States																																
							47.9	+0.1										75	4.85	+1.2											5.7		
Asheville	2,253	79	84	27.72	30.15	+.02	39.2	+0.7	64	4	50	13	19	29	34	33	27	71	0.96	−2.4	10	6,032	nw.	30	se.	22	12	9	8	4.7	0.1	0.0
Charlotte	779	55	62	29.28	30.14	+.02	42.7	−0.2	66	4	53	20	19	34	28	37	31	68	3.57	−0.7	12	3,656	sw.	25	nw.	18	10	3	11	5.6	T.	0.0
Hatteras	11	11	50	30.12	30.13	+.02	48.6	+1.2	67	4	55	27	27	42	25	45	42	79	6.66	+2.5	14	9,318	ne.	48	w.	18	11	3	10	5.3	0.0	0.0
Raleigh	376	103	110	29.73	30.15	+.04	43.7	+0.5	67	4	53	22	26	34	30	39	33	72	3.23	−1.2	11	4,850	sw.	34	nw.	18	10	3	11	5.8	T.	0.0
Wilmington	78	81	91	30.07	30.16	+.04	49.4	+1.5	68	4	58	27	19	40	31	44	41	81	6.14	+2.8	12	4,494	w.	23	w.	18	11	6	12	5.5	T.	0.0
Charleston	48	11	92	30.09	30.14	+.02	51.7	−0.7	70	5	59	26	19	44	24	46	43	70	7.44	+4.4	13	6,324	w.	36	w.	18	9	5	15	6.2	0.0	0.0
Columbia, S. C	351	41	57	29.77	30.16	+.05	47.4	−0.8	71	4	57	21	19	38	32	41	35	72	5.41	+0.7	10	4,194	ne.	31	sw.	18	12	6	11	5.3	0.0	0.0
Due West	711	10	55	29.39	30.15	------	44.2	------	67	5	54	17	19	34	34	----	----	----	2.65	------	10	5,799	sw.	30	w.	18	9	8	12	5.8	T.	0.0
Greenville, S. C	1,039	139	146	29.02	30.14	------	44.6	+1.3	67	5	54	19	19	35	31	38	33	71	3.30	------	10	5,840	ne.	39	w.	18	12	7	10	4.9	T.	0.0
Augusta	182	62	77	29.95	30.15	+.03	48.9	−1.0	72	4	59	22	19	39	33	42	37	74	5.84	+1.6	13	3,398	nw.	30	nw.	18	9	11	9	5.7	T.	0.0
Savannah	65	150	194	30.08	30.15	+.03	53.2	−0.8	73	14	61	24	19	45	28	47	43	78	6.69	+3.4	10	7,072	w.	48	w.	18	6	8	15	6.8	0.0	0.0
Jacksonville	43	209	245	30.10	30.15	+.03	57.0	−1.0	80	17	65	26	19	49	32	51	46	76	3.54	+0.4	10	7,186	ne.	49	sw.	17	6	8	15	6.4	0.0	0.0
Florida Peninsula																																
							63.5	+2.0										79	1.06	−1.3											4.5		
Key West	22	10	64	30.07	30.09	+.02	71.6	+1.1	84	25	77	51	19	66	16	66	64	83	0.07	−1.3	2	6,537	ne.	37	nw.	18	20	5	4	3.1	0.0	0.0
Miami	25	71	164	30.09	30.12	------	69.4	+2.3	83	25	75	38	19	64	28	64	61	78	2.02	−0.2	9	7,272	s.	26	nw.	18	11	13	5	4.2	0.0	0.0
Tampa	35	79	87	30.10	30.13	+.03	64.4	+2.5	83	24	74	33	19	55	30	56	53	76	1.00	−2.3	7	4,270	ne.	21	se.	22	9	12	8	5.6	0.0	0.0
Titusville	44	5	----	30.06	30.12	------	63.8	------	89	24	74	29	19	54	31	----	----	----	0.70	------	10	------	w.	------	------	----	8	11	10	5.7	0.0	0.0
East Gulf States																		71	4.29	−0.6											6.1		
							50.0	−1.2																								
Atlanta	1,173	190	216	28.89	30.16	+.04	44.1	−1.2	66	5	53	16	19	35	28	37	31	66	2.50	−2.4	12	7,735	nw.	30	nw.	18	10	6	13	5.9	T.	0.0
Macon	370	78	87	29.76	30.16	+.04	48.2	−1.1	70	4	58	20	19	38	35	42	36	70	3.54	−1.2	10	3,940	nw.	25	nw.	18	6	9	14	6.3	T.	0.0
Thomasville	273	49	58	29.84	30.15	+.03	54.3	−0.7	77	17	64	26	19	45	30	48	43	74	5.41	+0.8	13	2,874	nw.	19	sw.	17	4	10	15	7.1	T.	0.0
Apalachicola	36	42	49	30.10	30.14	------	54.8	------	71	9	61	27	19	48	21	50	47	79	8.00	------	11	5,147	e.	24	nw.	18	8	6	15	6.3	0.0	0.0
Pensacola	56	149	185	30.10	30.16	+.05	53.4	−1.8	67	8	60	25	19	47	20	48	45	70	7.51	+3.0	12	8,412	n.	41	se.	22	5	9	15	6.9	0.0	0.0
Anniston	741	9	57	29.40	30.19	+.07	45.5	−0.3	70	23	57	13	19	34	36	----	----	----	2.49	−2.3	10	3,968	nw.	22	nw.	18	15	5	9	4.8	T.	0.0
Birmingham	700	11	48	29.40	30.18	+.06	47.1	−0.9	71	6	57	17	19	37	31	40	34	67	1.77	−3.1	7	4,571	n.	24	se.	22	14	4	11	4.9	T.	0.0
Mobile	57	126	161	30.09	30.16	+.05	53.0	−1.7	72	3	61	27	19	45	27	47	42	74	8.52	+3.0	8	6,419	n.	34	se.	22	6	8	15	6.5	0.0	0.0
Montgomery	223	100	112	29.92	30.18	+.06	50.4	−1.2	72	4	60	21	19	41	33	43	36	66	3.18	−2.5	7	4,392	n.	22	nw.	18	7	7	15	6.6	0.1	0.0
Corinth	409	6	----	----	----	------	44.9	------	75	6	55	18	19	35	34	----	----	----	2.42	------	9	------	nw.	------	------	----	5	14	10	----	T.	0.0
Meridian	376	87	95	29.76	30.17	+.06	49.2	−0.4	73	6	59	20	19	39	33	43	37	69	1.99	−3.0	7	3,883	n.	23	nw.	18	11	8	10	5.3	T.	0.0
Vicksburg	247	65	73	29.90	30.19	+.09	50.2	−1.6	72	8	59	26	19	42	29	44	37	67	2.63	−2.3	9	4,560	se.	26	nw.	17	10	9	10	5.5	T.	0.0
New Orleans	53	76	84	30.10	30.16	+.07	54.8	−2.5	74	13	61	32	19	48	25	49	45	76	7.63	+3.2	9	4,082	ne.	24	sw.	22	8	7	14	6.6	0.0	0.0
West Gulf States																																
							52.0	+0.5										73	3.42	+0.3											4.6		
Shreveport	249	77	93	29.90	30.18	+.09	50.8	−0.1	73	29	60	29	18	42	30	44	38	69	2.93	−0.5	10	4,045	se.	20	w.	13	11	9	9	5.1	0.0	0.0
Bentonville	1,305	11	44	----	----	------	40.3	+1.8	66	11	49	14	18	31	34	----	----	----	2.48	------	12	------	s.	----	------	----	14	4	11	----	2.9	0.0
Fort Smith	457	79	94	29.64	30.13	+.03	45.2	+2.4	72	5	54	21	18	36	36	39	34	69	1.77	−0.9	9	5,521	s.	36	sw.	13	8	9	12	5.8	0.1	0.0
Little Rock	357	136	144	29.76	30.15	+.04	45.8	+0.9	71	11	54	22	19	38	32	40	34	67	2.57	−1.8	9	5,522	s.	33	w.	13	8	11	10	5.7	T.	0.0
Austin	606	136	146	29.50	30.14	------	53.4	0.0	76	29	62	31	25	44	31	----	----	----	5.43	+3.0	11	5,057	n.	34	n.	23	10	5	14	5.8	0.0	0.0
Brownsville	57	53	61	30.02	30.08	------	62.5	−0.1	81	22	70	40	25	55	25	58	55	83	1.73	+0.5	10	4,865	se.	23	n.	17	2	9	18	7.7	0.0	0.0
Corpus Christi	20	11	79	30.10	30.13	+.08	68.4	0.0	80	7	64	36	25	52	20	55	52	84	1.68	−0.4	12	7,470	se.	30	n.	23	3	8	18	7.8	0.0	0.0
Dallas	512	220	227	29.60	30.16	------	49.8	------	71	6	59	25	24	41	31	----	----	----	3.90	------	6	8,170	se.	46	e.	21	11	7	11	5.2	0.0	0.0
Fort Worth	670	108	114	29.42	30.14	+.07	51.4	+3.1	74	22	61	27	24	42	32	45	39	70	3.53	+2.0	6	5,966	s.	30	w.	13	9	10	10	5.6	T.	0.0
Galveston	54	108	114	30.10	30.16	+.09	55.4	−0.9	75	7	61	35	25	50	31	52	49	83	5.41	+2.5	10	6,369	n.	31	nw.	18	8	7	14	6.3	0.0	0.0
Groesbeck	461	11	56	29.66	30.15	------	50.5	------	76	29	59	29	24	42	29	----	----	----	4.38	------	12	6,620	n.	33	ne.	21	11	2	16	5.6	0.0	0.0
Houston	138	202	314	30.01	30.16	------	54.9	−1.0	77	7	62	31	25	47	32	----	----	----	3.85	+0.7	9	7,694	e.	25	nw.	23	7	7	15	6.2	0.0	0.0
Palestine	510	64	72	29.62	30.16	+.08	50.5	−0.7	75	29	59	28	25	42	29	45	39	68	4.85	+1.8	8	4,916	n.	27	nw.	13	9	5	15	5.8	0.0	0.0
Port Arthur	34	58	66	30.12	30.16	------	54.8	------	78	23	62	32	25	48	35	----	----	----	5.64	------	9	5,303	ne.	28	nw.	21	9	3	17	6.4	0.0	0.0
San Antonio	603	119	133	29.39	30.12	+.07	55.6	+0.2	78	7	64	33	25	47	30	49	43	68	2.85	+1.1	9	4,456	ne.	25	nw.	13	9	9	11	5.9	0.0	0.0
Taylor	583	58	63	29.58	30.17	+.11	51.9	+0.6	76	29	61	29	25	43	33	----	----	----	4.45	+1.8	10	4,920	n.	29	n.	21	11	7	11	5.6	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, February, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind (3-cup anemometer used): Total movement	Wind (3-cup anemometer used): Prevailing direction	Wind (3-cup anemometer used): Maximum velocity: Miles per hour	Wind (3-cup anemometer used): Maximum velocity: Direction	Wind (3-cup anemometer used): Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							36.6	+0.5							74			74	2.68	−0.9										6.6		
Chattanooga	762	189	213	29.34	30.17	+.04	43.3	−0.8	66	4	52	17	19	34	30	37	30	66	2.62	−2.4	10	5,404	sw.	30	sw.	8	11	6	12	5.4	0.2	0.0
Knoxville	995	102	111	29.07	30.16	+.04	42.0	+0.1	67	4	51	17	19	33	31	36	30	70	2.40	−2.3	11	4,369	sw.	28	sw.	14	10	7	12	5.6	0.2	0.0
Memphis	399	76	97	29.72	30.16	+.05	44.8	+0.5	73	6	52	19	18	37	30	39	32	66	2.42	−2.1	10	5,316	sw.	31	w.	14	7	11	11	5.9	T.	0.0
Nashville	546	168	191	29.50	30.18	+.06	41.6	0.0	69	4	50	18	19	33	33	36	31	71	2.64	−1.6	9	6,343	w.	33	nw.	18	10	7	12	5.6	0.1	0.0
Lexington	989	193	230	29.06	30.17	+.06	35.5	+0.1	64	4	43	11	26	28	30				2.30	−1.0	11	9,175	sw.	35	nw.	18	11	2	16	5.9	1.6	T.
Louisville	525	188	234	29.56	30.16	+.05	36.4	−0.8	63	4	44	14	26	29	30	32	27	72	2.51	−1.1	12	7,156	sw.	32	w.	18	10	2	17	6.4	0.7	0.4
Evansville	431	76	116	29.69	30.18	+.07	37.2	+0.9	69	7	44	15	24	30	28	34	29	73	2.59	−0.8	11	6,532	sw.	28	nw.	17	8	7	14	6.1	2.3	0.4
Indianapolis	822	194	230	29.20	30.11	+.01	32.2	+1.1	55	7	39	9	26	24	29	25	25	75	3.44	+0.6	12	8,120	w.	23	nw.	18	6	8	15	6.8	5.0	0.3
Royal Center	736	11	55	29.26	30.09		29.3		51	7	36	4	26	22	28				2.18		9	7,914	w.	37	w.	19	5	7	17	6.9	4.0	0.0
Terre Haute	575	96	129	29.48	30.12		33.8		60	7	41	10	24	27	25	30	26	77	3.82		12	6,459	nw.	28	sw.	19	8	6	15	6.3	4.3	0.6
Cincinnati	627	11	51	29.43	30.14	+.04	33.6	+0.8	55	3	41	9	26	26	24	30	27	80	3.23	+0.2	13	5,614	sw.	26	sw.	14	8	3	18	7.0	2.2	1.1
Columbus	822	179	222	29.21	30.11	+.02	32.0	+1.3	54	4	39	5	26	25	23	29	25	79	2.28	−0.5	14	6,974	w.	36	w.	20	7	6	16	6.7	3.7	0.8
Dayton	899	137	173	29.13	30.12		32.5	+1.1	52	3	39	8	26	26	24	29	25	77	2.73	−0.4	12	6,568	sw.	27	sw.	19	5	7	17	7.4	4.7	1.0
Elkins	1,947	59	67	28.00	30.14	+.04	32.8	+1.2	59	8	41	9	19	24	36	29	25	76	2.53	−0.8	18	4,831	w.	25	w.	23	3	6	20	8.2	7.5	0.0
Parkersburg	637	77	82	29.47	30.14	+.04	35.8	+1.6	62	4	43	16	19	28	28	32	27	75	2.73	−0.6	19	4,242	sw.	26	sw.	23	6	4	19	7.4	2.1	0.1
Pittsburgh	842	353	410	29.17	30.11	+.02	32.4	+0.1	59	8	39	6	19	25	25	28	24	74	3.07	+0.4	16	7,915	w.	36	sw.	15	4	6	19	7.9	5.4	0.1
Lower Lake Region							36.4	+1.4							78			78	2.06	−0.4										6.8		
Buffalo	767	247	280	29.18	30.04	−.02	25.4	+1.1	50	8	32	2	26	18	30	24	21	83	2.00	−1.0	18	12,215	sw.	54	sw.	20	4	9	16	7.1	8.0	T.
Canton	448	10	61	29.54	30.04		16.9	−1.1	41	23	26	−11	3	7	41				2.45	−0.2	18	6,433	w.	31	sw	22	12	7	10	5.6	13.3	2.0
Oswego	335	76	91		30.03	−.03	23.8	−0.1	46	4	31	−6	26	16	28			84	2.78	+0.2	15			28	w.	20	3	1	25		18.8	1.0
Rochester	523	86	102	29.46	30.05	−.01	26.6	+2.0	54	8	34	2	26	19	31	23	18	72	2.23	−0.6	18	6,579	w.	34	w.	20	3	8	18	7.4	8.3	T.
Syracuse	597	97	113	29.40	30.06	−.01	25.2	+1.4	53	8	32	−5	26	18	27				1.88	0.0	18	7,962	s.	35	w.	20	4	6	19	7.4	7.7	T.
Erie	714	130	166	29.27	30.06	−.01	27.6	+0.7	53	8	35	3	26	20	29	25	20	72	1.62	−1.0	12	10,492	sw.	37	se.	14	6	6	17	6.8	3.5	T.
Cleveland	762	190	201	29.23	30.08	+.01	29.2	+1.8	51	4	36	6	25	22	24	27	23	78	2.36	−0.2	13	8,584	sw.	30	w.	20	4	5	20	7.5	2.8	0.0
Sandusky	629	5	67	29.37	30.08	+.01	29.7	+2.3	52	4	37	4	26	23	25				1.79	−0.4	16	6,831	sw.	27	nw.	20	4	10	15	6.8	4.5	0.0
Toledo	628	206	243	29.38	30.08	+.01	28.9	+1.0	49	4	36	4	26	22	24	26	22	76	2.18	+0.1	16	9,406	sw.	30	sw.	19	6	10	13	6.4	4.1	0.0
Fort Wayne	856	113	124	29.12	30.07		29.7	+3.9	52	7	37	5	26	23	28	27	24	81	2.05		12	6,704	sw.	28	sw.	19	5	9	15	6.6	7.0	T.
Detroit	730	218	258	29.24	30.06	.00	27.0	+1.7	45	4	34	5	25	20	22	25	22	81	1.34	−0.9	15	7,557	sw.	40	sw.	26	6	7	16	6.9	5.6	0.0
Upper Lake Region							21.0	+2.9							82			82	1.48	−0.4										6.2		
Alpena	609	13	92	29.34	30.04	+.01	18.2	+0.2	39	3	28	−15	25	9	37	17	14	82	1.52	−0.2	12	7,400	w.	30	w.	19	6	10	13	6.1	11.4	4.7
Escanaba	612	54	60	29.35	30.05	−.01	15.9	+0.5	35	13	25	−21	25	7	43	15	12	84	1.90	+0.4	8	6,236	n.	30	nw.	19	11	6	12	5.3	19.5	20.0
Grand Haven	632	54	89	29.34	30.05	.00	26.7	+2.5	45	7	33	7	25	21	22	25	22	82	1.48	−0.8	14	8,906	w.	48	w.	19	5	8	16	6.8	5.8	T.
Grand Rapids	707	70	87	29.26	30.06	+.01	27.0	+3.3	47	7	34	5	25	20	27	24	21	79	1.54	−0.8	15	4,498	nw.	24	nw.	19	5	6	18	7.2	9.6	T.
Houghton	668	64	99	29.28	30.04	−.01	14.1	+0.4	38	13	24	−20	25	5	43				0.96	−0.8	13	6,489	w.	37	w.	19	6	9	14	6.7	10.9	16.5
Lansing	878	0	49	29.07	30.05		24.6	+1.7	44	3	33	−2	21	18	29	23	22	90	1.60	−0.4	16	4,440	nw.	22	nw.	24	7	10	12	5.8	10.3	0.1
Ludington	637	60	66	29.31	30.03		24.8		44	13	31	−1	25	18	25	23	19	80	2.25		14	7,886	w.	38	sw.	19	6	8	15	6.5	4.9	0.0
Marquette	734	77	111	29.22	30.05	.00	18.3	+2.0	39	13	26	−12	25	11	29	16	13	85	1.92	0.0	13	6,627	w.	34	w.	19	6	8	15	7.1	17.5	18.2
Port Huron	638	70	120	29.33	30.03	−.02	25.0	+2.3	43	8	32	0	25	18	25	23	20	81	0.65	−1.3	12	7,896	nw.	31	nw.	19	3	13	13	6.8	2.3	T.
Sault Sainte Marie	614	11	52	29.31	30.05	+.02	11.9	−0.7	35	14	22	−30	25	2	38	11	9	89	2.55	+1.1	16	5,337	nw.	36	nw.	19	6	8	15	7.1	25.1	24.5
Chicago	673	7	131	29.33	30.08	.00	30.3	+4.0	52	3	37	5	25	24	27	27	22	73	1.57	−0.6	7	7,913	nw.	34	ne.	18	9	6	14	5.9	8.5	0.0
Green Bay	617	109	141	29.36	30.05	−.01	19.6	+2.2	39	13	27	−23	25	12	40	18	15	80	1.89	+0.2	7	7,579	w.	37	nw.	19	8	11	10	5.9	14.6	8.8
Milwaukee	681	125	221	29.30	30.06	.00	27.2	+4.4	50	3	34	−4	25	20	30	24	19	72	1.36	−0.5	11	9,494	nw.	34	n.	18	11	5	13	5.6	5.0	T.
Duluth	1,133	5	47	28.80	30.08	.00	14.4	+3.0	38	10	23	−18	24	6	29	13	11	88	0.30	−0.8	4	8,356	w.	39	w.	19	13	7	9	4.8	3.0	5.5
North Dakota							19.2	+11.5							80			80	0.20	−0.4										5.1		
Moorhead	940	50	58	29.05	30.11	.00	18.9	+10.8	42	10	28	−11	24	10	36	17	14	82	0.44	−0.3	6	5,431	n.	35	nw.	19	5	11	13	6.4	1.9	T.
Bismarck	1,674	8	57	28.28	30.14	+.02	21.0	+10.7	52	11	31	−8	23	11	39	18	14	76	0.11	−0.4	2	5,951	nw.	36	nw.	19	12	11	6	4.5	2.1	0.2
Devils Lake	1,478	11	44	28.45	30.10	−.01	16.8	+12.3	40	10	26	−7	17	8	35	14	12	86	0.01	−0.6	1	6,052	nw.	34	nw.	19	10	10	9	5.1	0.1	T.
Kilendale	1,457	10	56	28.51	30.13		21.2		48	10	31	−7	1	12	41				0.23		6	9,186	nw.	51	nw.	19	6	11	12	5.9	1.1	T.
Grand Forks	833	12	67				19.2		42	27	27	−13	2	8	40	15			0.03		3		nw.	33	s.	18	11	8	10		0.1	0.0
Williston	1,878	41	48	28.09	30.16	+.05	20.2	+12.1	50	11	29	−8	22	11	34	17	14	77	0.22	−0.2	3	5,486	w.	33	nw.	19	15	9	5	3.7	2.2	0.7
Upper Mississippi Valley							30.0	+5.4							77			77	2.06	+0.4										5.4		
Minneapolis	918	102	208	29.06	30.09		21.7	+5.8	47	12	28	−5	18	15	29				1.51	+0.5	7	7,544	nw.	41	nw.	19	10	7	12	5.6	3.2	1.5
St. Paul	837	236	261	29.13	30.08	−.01	20.8	+5.0	45	12	28	−8	25	14	31				1.63	+0.7	7	7,914	nw.	46	w.	19	10	8	11	5.5	5.2	1.2
La Crosse	714	11	48	29.28	30.08	.00	24.2	+5.0	51	3	33	−19	25	16	39	21	18	80	2.18	+1.1	7	2,977	nw.	21	nw.	19	12	6	11	5.2	10.3	2.0
Madison	974	70	78	28.99	30.09	+.02	25.0	+5.9	47	3	32	−6	25	18	29	22	20	82	1.76	+0.2	8	6,177	nw.	28	nw.	19	13	3	13	5.4	7.7	T.
Wausau	1,247	4		28.66	30.05		18.8		40	3	27	−26	25	11	34				0.91		7		nw.			16	6	7	4.0	4.1	3.0
Charles City	1,015	10	49	28.98	30.10	.00	25.2	+8.1	50	3	32	1	25	18	34	23	20	82	2.68	+1.7	8	4,980	nw.	28	w.	19	13	5	11	4.7	3.5	T.
Davenport	606	71	79	29.41	30.10	.00	31.0	+6.1	54	3	39	5	25	23	31	28	24	79	1.61	0.0	9	5,218	nw.	26	nw.	19	10	7	12	5.5	3.7	0.0
Des Moines	861	84	97	29.16	30.09	−.02	30.4	+6.7	62	12	38	0	18	22	39	27	22	74	3.10	+1.9	10	4,792	nw.	20	sw.	3	9	7	13	5.6	6.5	T.
Dubuque	700	81	96	29.30	30.09	.00	28.2	+6.0	51	3	35	0	25	21	31	25	21	77	1.69	+0.3	8	4,721	nw.	24	nw.	19	11	7	11	5.6	3.0	T.
Keokuk	614	64	78	29.42	30.12	+.01	34.2	+5.9	59	3	42	6	18	26	27	29	24	70	1.75	+0.2	8	5,424	nw.	25	sw.	19	11	5	13	5.6	1.7	0.0
Cairo	358	87	93	29.77	30.16	+.04	40.0	+1.5	67	6	48	13	18	32	27	35	30	70	2.58	−0.6	11	6,178	s.	28	nw.	23	10	5	14	5.9	0.3	T.
Peoria	609	11	45	29.43	30.12	+.02	32.3	+6.4	53	28	40	7	25	25	30	29	26	82	1.73	−0.3	10	5,337	nw.	24	w.	19	12	5	12	5.2	1.1	0.0
Springfield, Ill.	636	10	91	29.41	30.11	+.01	34.1	+4.6	55	28	41	8	24	27	28	31	28	81	2.42	+0.1	11	6,055	w.	24	nw.	17	8	6	15	6.2	2.8	0.0
Hannibal	534	74	109	29.52	30.11	.00	35.8	+6.1	61	12	44	7	18	28	30				2.02	+0.4	9	6,309	sw.	26	sw.	19	10	7	12	5.4	0.9	0.0
St. Louis	568	265	308	29.51	30.13	+.02	37.6	+3.1	62	28	46	11	18	30	30	33	28	73	2.43	−0.2	9	8,412	w.	32	nw.	17	13	4	12	5.3	5.1	2.3
Missouri Valley							32.4	+6.5							73			73	1.46	+0.3										5.0		
Columbia, Mo.	784	11	84	29.26	30.12	+.01	36.4	+4.7	66	12	45	7	18	28	31				2.10	−0.1	10	5,763	nw.	26	nw.	17	13	4	12	5.3	4.0	0.0
Kansas City	963	161	181	29.06	30.13	+.02	37.2	+6.0	66	11	46	8	18	29	29	33	27	69	2.77	+1.0	8	7,254	nw.	34	nw.	17	10	9	10	5.3	2.0	0.0
St. Joseph	967	11	49	29.05	30.11		35.2		66	11	44	7	18	26	30	30	24	68	1.69		7	5,966	nw.	29	nw.	17	14	4	11	5.0	1.1	0.0
Springfield, Mo.	1,324	98	104	28.70	30.14	+.03	38.2	+3.0	62	11	46	9	18	30	29	34	28	71	1.09	−1.3	5	6,870	s.	28	s.	6	13	6	10	4.7	1.0	0.0
Iola	964	11	50	29.06	30.14	+.04	38.0	+4.8	68	28	48	10	24	28	36				2.22	+0.7	8	4,480	s.	23	n.	23	9	10	10	5.4	0.3	0.0
Topeka	987	92	107				36.5	+5.5	69	11	46	10	23	27	35				2.43	+1.0	5	6,306	nw.	30	n.	23	10	9	10	5.2	0.3	0.0
Lincoln	1,189	11	81	28.83	30.13	+.03	32.7	+6.6	65	11	42	5	23	23	43	28	21	66	0.92	+0.2	5	6,512	nw.	28	nw.	19	12	6	11	5.6	3.9	0.0
Omaha	1,105	115	122	28.90	30.13	+.02	31.6	+6.1	64	12	40	4	23	24	32	28	23	73	0.93	0.0	7	6,107	nw.	31	n.	23	12	9	8	4.8	5.5	0.0
Valentine	2,598	47	54	27.36	30.17	+.08	29.2	+7.8	68	11	42	−5	23	16	44	23	17	60	0.28	−0.2	6	5,964	w.	28	nw.	19	15	9	5	3.7	3.7	0.0
Sioux City	1,136	94	164	28.88	30.14	+.02	27.8	+6.8	60	3	36	0	18	20	35	25	22	79	1.60	+1.0	8	7,722	nw.	36	nw.	19	10	12	7	5.0	8.4	T.
Huron	1,306	59	74	28.70	30.16	+.04	25.1	+10.8	53	3	35	−7	23	15	37	21	17	76	0.59	0.0	4	6,292	nw.	27	nw.	19	12	9	8	4.7	0.8	0.0
Pierre	1,572	70	75		30.19	+.08	28.1	+9.5	66	11	39	−2	23	17	30			82	0.08	−0.4	3	5,663	nw.	35	nw.	19	11	13	5		0.8	0.0
Yankton	1,233	49	57	28.77	30.14	+.02	27.4	+6.5	63	3	36	−2	23	19	40				2.47	+1.6	7	5,446	nw.	25	nw.	19	10	13	6	5.0	11.7	T.

TABLE 1.—*Climatological data for Weather Bureau stations, February, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind (3-cup anemometer used): Total movement	Wind (3-cup anemometer used): Prevailing direction	Wind (3-cup anemometer used): Maximum velocity: Miles per hour	Wind (3-cup anemometer used): Maximum velocity: Direction	Wind (3-cup anemometer used): Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Northern Slope	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								0–10	*In.*	*In.*
							25.6	+3.2										70	0.50	−0.4										4.5		
Billings	3,140	5			27.8				52	5	40	−12	23	10	44				0.24		6		nw.				17	4	8		3.5	
Havre	2,505	11	44	27.47	30.30	+.13	27.2	+13.6	57	11	37	−11	22	17	39	24	19	74	0.23	−0.3	1	5,493	sw.	32	w.	11	10	13	6	4.7	2.9	T.
Helena	4,110	87	112	25.92	30.29	+.18	23.3	+0.3	45	18	32	−14	23	14	35	20	15	72	0.14	−0.6	5	4,429	sw.	28	sw.	16	10	9	10	5.2	2.4	T.
Kalispell	2,973	48	56	27.10	30.28	+.20	24.6	+1.3	45	5	34	−9	23	16	28	23	19	80	0.14	−1.4	4	2,634	nw.	24	sw.	11	10	9	10	5.4	1.8	6.3
Rapid City	3,259	50	58	26.67	30.23	+.15	28.6	+5.2	64	11	41	−8	23	16	38	23	15	60	0.22	−0.3	3	5,534	n.	29	n.	17	17	7	5	3.5	2.2	T.
Cheyenne	6,088	84	101	24.00	30.17	+.14	27.2	−0.1	59	11	39	−3	25	16	37	21	13	58	1.28	+0.6	9	7,821	w.	40	w.	18	11	8	10	5.2	15.1	6.5
Lander	5,372	60	68	24.69	30.25	+.17	22.3	−0.2	50	5	36	−9	24	9	45	18	14	72	1.49	+0.8	7	2,118	sw.	24	n.	6	14	8	7	4.0	17.2	5.0
Sheridan	3,790	10	47	26.18	30.25		22.2		53	10	36	−13	23	8	43	19	14	74	0.66		6	2,843	s.	27	nw.	16	15	7	7	3.9	7.4	3.0
Yellowstone Park	6,241	11	48	23.92	30.30	+.20	19.8	+0.2	44	3	30	−14	23	9	37	17	12	73	0.37	−1.5	9	4,559	s.	26	sw.	11	9	12	8	4.9	5.1	9.7
North Platte	2,821	11	51	27.14	30.16	+.09	31.7	+5.1	68	11	45	2	25	18	43	25	19	68	0.17	−0.4	5	4,578	n.	27	n.	7	14	7	6	4.0	1.8	T.
Middle Slope							36.7	+2.9										66	1.31	+0.5										4.5		
Denver	5,292	106	113	24.74	30.15	+.14	33.2	+0.5	62	4	44	2	16	22	35	26	16	56	0.59	0.0	9	4,631	s.	24	nw.	18	11	11	7	4.7	8.6	0.4
Pueblo	4,685	80	90	25.31	30.11	+.11	33.6	+0.7	65	2	48	7	16	19	45	27	18	58	0.51	0.0	7	3,456	se.	22	nw.	6	14	11	4	3.9	6.7	0.0
Concordia	1,392	50	58	28.65	30.17	+.08	35.2	+5.4	66	4	44	6	23	26	39	30	24	69	2.03	+1.1	6	5,140	nw.	22	nw.	17	12	5	12	5.1	0.7	0.0
Dodge City	2,509	11	51	27.48	30.16	+.10	36.6	+3.4	71	4	48	9	23	25	43	30	25	72	1.60	+0.8	5	5,772	nw.	26	n.	22	19	4	6	3.1	5.5	0.0
Wichita	1,358	130	138	28.65	30.12	+.04	38.6	+4.2	68	4	48	10	23	29	35	34	29	73	1.79	+0.7	8	7,587	s.	33	n.	23	14	7	8	4.3	1.9	0.0
Broken Arrow	765	11	56	29.31	30.15		42.4		67	28	52	16	24	33	31				2.09		11	8,004	s.	39	n.	23	10	6	13	5.3	4.6	0.0
Oklahoma City	1,214	10	47	28.83	30.14	+.07	42.8	+3.2	71	4	52	16	24	33	36	37	31	70	1.33	+0.3	8	6,589	s.	30	n.	23	13	6	10	4.0	1.9	0.0
Southern Slope							46.2	+0.3										63	0.89	0.0										4.6		
Abilene	1,738	10	52	28.29	30.13	+.08	49.0	+1.8	77	5	60	24	25	38	35	40	32	60	0.78	−0.3	4	5,938	s.	28	s.	19	11	8	10	5.3	0.2	0.0
Amarillo	3,676	10	49	26.31	30.12	+.10	39.4	+1.3	74	28	51	14	24	28	41	32	25	65	1.11	+0.2	7	5,512	s.	27	w.	22	16	4	9	4.2	7.2	0.0
Del Rio	944	64	71	29.09	30.10	+.10	55.4	−0.6	89	29	65	33	26	46	39	48	41	65	0.32	−0.1	9	5,057	se.	29	nw.	16	13	6	10	5.2	0.0	0.0
Roswell	3,566	75	85	26.42	30.09	+.11	41.2	−1.3	70	28	54	5	17	28	32	34	26	61	0.84	+0.3	4	4,729	e.	40	nw.	5	18	4	7	3.8	5.7	0.0
Southern Plateau							45.0	+0.2										53	0.87	+0.3										3.2		
El Paso	3,778	152	175	26.22	30.05	+.10	48.8	−0.2	75	28	60	24	17	37	36	38	25	46	0.71	+0.3	5	7,005	w.	44	w.	22	15	12	2	3.3	T.	0.0
Santa Fe	7,013	38	53	23.22	30.07	+.09	32.6	−0.5	56	28	42	10	17	23	28	26	19	61	1.22	+0.4	6	3,390	n.	18	n.	7	15	6	8	4.9	11.3	0.0
Flagstaff	6,907	10	59	23.32	30.02	+.02	30.3	−0.5	54	28	42	3	14	18	41	25		66	1.90		8		sw.				13	10	6		11.0	T.
Phoenix	1,108	10	32	28.86	30.02	+.03	55.1	0.0	81	28	69	33	17	41	39	44	32	49	1.33	+0.6	5	2,787	e.	32	w.	4	15	9	5	3.4	0.0	0.0
Yuma	141	9	54	29.90	30.05	+.05	58.0	−0.6	82	28	72	36	16	44	39	47	31	41	0.22	−0.2	3	3,768	n.	30	nw.	16	22	5	2	2.3	0.0	0.0
Independence	3,957	5	25	26.02	30.09	+.03	45.5	+3.2	68	18	60	24	17	31	40	34			0.06		3		n.				19	6	4	2.0	0.0	0.0
Middle Plateau							36.0	+2.6										56	0.25	−0.9										3.9		
Reno	4,532	74	81	25.56	30.18	+.10	37.8	+2.2	62	20	51	14	16	24	42	32	23	58	0.07	−1.2	3	3,007	w.	31	w.	5	16	6	7	4.0	0.6	0.0
Tonopah	6,090	12	20				35.1		51	18	43	10	15	27	25	27	13	38	0.42		2		nw.									
Winnemucca	4,344	18	56	25.76	30.25	+.16	34.9	+1.4	59	20	48	8	15	22	42	29	23	64	0.16	−0.8	5	3,731	ne.	28	nw.	14	15	13	1	3.2	0.8	0.0
Modena	5,473	10	43	24.66	30.08	+.04	34.5	+3.5	56	29	47	12	17	22	40	28	20	60	0.57	−0.7	3	5,514	w.	32	ne.	15	16	8	5	3.7	0.2	0.0
Salt Lake City	4,360	163	203	25.72	30.18	+.10	36.0	+2.2	54	21	43	20	16	29	33	30	24	63	0.28	−1.3	7	3,718	nw.	24	w.	22	12	7	10	5.0	2.3	0.0
Grand Junction	4,602	60	68	25.44	30.08	+.04	36.6	+3.7	56	29	48	16	17	25	32	29	19	54	0.19	−0.4	4	3,332	se.	21	n.	6	16	8	5	3.7	1.0	0.0
Northern Plateau							33.2	+0.2										74	0.37	−1.1										5.2		
Baker	3,471	48	53	26.61	30.30	+.18	28.7	−0.3	43	4	37	12	15	20	35	26	22	73	0.30	−1.1	11	3,534	se.	16	nw.	14	11	3	15	5.9	4.5	T.
Boise	2,739	78	86	27.36	30.30	+.18	34.0	−0.8	51	3	42	17	15	26	24	30	26	75	0.82	−0.7	10	2,629	w.	18	nw.	14	13	7	9	4.5	3.3	0.0
Lewiston	757	40	48	29.45	30.28	+.17	37.8	+0.8	54	20	47	19	24	29	28				0.18	−1.2	6	1,728	e.	25	nw.	11	12	6	11	5.0	0.3	0.0
Pocatello	4,477	60	68	25.58	30.24	+.14	29.8	+0.9	47	21	38	10	15	21	26	26	21	70	0.41	−0.5	9	4,776	se.	26	sw.	22	10	9	10	5.2	4.5	T
Spokane	1,929	101	110	28.18	30.30	+.21	31.4	+0.1	48	17	39	11	24	24	27	29	25	77	0.22	−1.6	7	2,190	nw.	21	sw.	11	9	8	12	5.9	1.0	T.
Walla Walla	991	57	65	29.18	30.28	+.17	37.3	+0.2	54	18	44	21	24	31	21	34	30	74	0.29	−1.5	7	2,147	s.	21	w.	11	13	5	11	5.0	1.7	0.0
North Pacific Coast Region							43.9	+2.0										75	1.77	−3.3										5.6		
North Head	211	11	56	29.92	30.16	+.10	45.4	+2.4	62	9	50	35	24	41	16	42	38	79	2.61	−3.5	17	7,841	e.	62	s.	5	4	8	17	7.8	0.0	0.0
Port Angeles	29	8	53		30.22		41.5		54	4	47	29	29	36	21				0.72	−1.3	10	3,436	s.	27	w.	7	3	10	16		0.0	0.0
Seattle	125	215	250	30.08	30.22	+.16	43.2	+2.1	57	10	48	31	12	38	17	40	37	78	0.91	−2.8	12	4,116	se.	34	sw.	11	3	7	19	7.6	T.	0.0
Tacoma	194	172	201	30.00	30.21	+.15	42.2	+1.6	60	10	48	31	18	36	24				0.85	−3.5	12	3,884	n.	28	sw.	5	3	10	16	7.2	0.0	0.0
Tatoosh Island	86	9	53	30.08	30.18	+.18	44.1	+3.1	52	29	47	38	14	41	12	42	38	82	4.11	−4.9	18	11,050	e.	56	e.	24	8	4	17	6.6	0.0	0.0
Yakima	1,071	5					37.1		56	19	48	18	25	26	34	32		73	0.05		4		ne.				10	9	10	5.1	0.5	0.0
Medford	1,425	4	80	28.65	30.18		43.5		66	9	56	20	15	31	39	38	32	69	0.73		8		nw.	30	se.	3	10	9	10	5.5	0.0	0.0
Portland, Oreg.	153	68	106	30.06	30.23	+.15	44.2	+2.1	60	17	51	31	15	38	23	40	35	71	1.19	−4.3	12	3,371	nw.	22	e.	24	7	9	13	6.2	T.	0.0
Roseburg	510	75	99	29.65	30.21	+.11	44.2	+0.8	62	10	53	25	16	35	35	41	37	76	2.01	−2.6	16	1,832	n.	17	s.	5	3	12	14	6.7	0.0	0.0
Middle Pacific Coast Region							51.8	+1.9										73	2.11	−2.1										4.7		
Eureka	62	73	89	30.11	30.18	+.07	49.4	+2.2	70	9	56	36	26	43	27	47	44	82	2.78	−4.5	13	4,151	se.	36	n.	14	8	4	17	6.4	0.0	0.0
Red Bluff	332	50	56	29.80	30.16	+.05	51.1	+1.7	73	18	62	33	17	41	38	45	38	65	2.66	−1.4	8	3,585	nw.	30	nw.	15	17	5	7	3.8	0.0	0.0
Sacramento	69	106	117	30.06	30.12	+.03	51.4	+1.3	67	19	61	36	18	42	30	47	42	72	1.38	−1.7	8	4,365	se.	28	nw.	14	15	4	10	4.0	0.0	0.0
San Francisco	155	208	243	29.96	30.13	+.03	55.1	+2.9	67	9	61	44	13	49	20	50	45	73	1.97	−2.0	8	4,307	se.	37	n.	15	14	8	7	4.6	0.0	0.0
San Jose	141	12	110	29.99	30.14		52.2	+1.6	70	9	64	34	11	41	34				1.78	−0.7	7	3,806	se.	26	se.	3	14	6	9	4.6	0.0	0.0
South Pacific Coast Region							58.6	+2.7										61	1.01	−1.2										3.3		
Fresno	327	89	98	29.78	30.15	+.07	52.4	+1.3	74	2	64	33	16	41	29	46	40	67	0.81	−0.6	5	3,065	nw.	22	nw.	21	19	7	3	3.2	0.0	0.0
Los Angeles	338	159	191	29.72	30.08	+.02	60.0	+4.5	82	19	69	43	16	51	30	49	38	51	1.42	−1.7	2	3,537	ne.	18	nw.	22	18	6	5	3.0	0.0	0.0
San Diego	87	62	70	29.98	30.07	+.01	57.5	+2.4	80	2	66	37	16	49	28	50	44	66	0.79	−1.3	4	3,535	nw.	25	w.	4	15	9	3	3.7	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.97	30.06		74.8	−0.1	86	28	80	66	12	70	18				2.89	+0.3	20	8,373	e.	35	e.	24	4	22	2	5.0	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	29.76	29.84	−.03	81.3	+1.0	92	16	90	70	10	73	19				0.32	−0.5	2		nw.		n.		3	25	1	5.2	0.0	0.0
Colon	38	7	97	29.87	29.88	−.02	80.1	0.0	89	26	87	74	12	77	13				0.71	−0.9	14		n.		n.		1	20	8	6.6	0.0	0.0
Alaska																																
Juneau	80	11	54	[1]29.97	[1]30.06		35.0		50	28	39	20	24	31	22	34	30	82	5.32		18	3,619	se.	26	e.	6	6	3	20	7.4	0.9	0.0
Hawaiian Islands																																
Honolulu	38	88	100	[1]30.03	[1]30.07		70.8		79	21	76	61	26	65	16	64	60	71	0.61	−3.3	8	4,567	e.	24	e.	1	14	10	5	4.1	0.0	0.0

[1] Pressure not corrected to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, February, 1928*

Station	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99												
Sydney, C. B. I.	48	29.87	29.92	0.00	18.1	−1.2	27.1	9.1	42	−10	5.24	+1.15	36.0
Halifax, N. S.	88	29.87	29.98	+.08	21.5	−0.9	30.8	12.1	44	−9	4.08	−1.08	10.3
Yarmouth, N. S.	65	29.85	29.92	−.07	25.3	−0.5	33.0	17.5	45	4	5.40	+1.23	12.4
Charlottetown, P. E. I.	38	29.84	29.88	−.07	17.4	−0.2	25.1	9.6	40	−6	2.91	−0.15	22.0
Chatham, N. B.	28	29.84	29.88	−.08	11.9	−0.6	23.2	0.6	39	−20	1.15	−2.01	8.8
Father Point, Que.	20	29.92	29.95	−.03	11.0	−0.5	19.6	2.4	39	−13	1.03	−1.18	10.3
Quebec, Que.	296	29.68	30.02	+.03	10.8	−1.0	17.9	3.8	37	−14	4.23	+0.96	39.1
Doucet, Que.	1,236				−5.4		13.9	−24.6	33	−57	0.70		7.0
Montreal, Que.	187	29.79	30.01	−.01	16.0	+1.5	23.8	8.2	39	−11	2.53	−0.54	14.1
Ottawa, Ont.	236	29.78	30.07	+.05	14.4	+2.7	24.4	4.4	40	−19	2.36	−0.33	13.9
Kingston, Ont.	285	29.72	30.06	+.02	20.5	+2.7	27.6	13.5	39	−9	2.22	−0.32	7.1
Toronto, Ont.	379	29.61	30.04	.00	24.1	+2.6	30.8	17.4	42	−4	1.67	−0.94	3.1
Cochrane, Ont.	930				1.5		13.3	−10.3	36	−35	0.48		4.8
White River, Ont.	1,244	28.59	29.98	−.04	0.6	+0.4	17.6	−16.4	30	−52	0.60	−0.92	6.0
London, Ont.	808				23.6		30.8	16.5	45	−2	3.07		14.3
Southampton, Ont.	656	29.28	30.02	.00	20.2	+0.3	27.5	13.0	40	−10	2.91	+0.01	18.1
Parry Sound, Ont.	688	29.28	30.02	+.01	14.3	0.0	24.0	4.5	38	−24	3.13	+0.21	24.0
Port Arthur, Ont.	644	29.32	30.06	+.01	13.1	+6.7	22.2	3.9	37	−19	0.42	−0.48	4.2
Winnipeg, Man.	760	29.22	30.10	.00	12.8	+14.1	20.6	4.5	39	−16	0.18	−0.80	1.8
Minnedosa, Man.	1,690	28.18	30.10	+.01	10.2	+12.9	20.1	0.3	38	−25	0.03	−0.58	0.3
Le Pas, Man.	860				7.2		18.7	−4.4	42	−27	0.38		3.8
Qu'Appelle, Sask.	2,115	27.72	30.07	−.01	15.0	+15.6	24.5	5.4	48	−19	0.16	−0.57	1.6
Moose Jaw, Sask.	1,789				20.6		30.0	11.2	51	−10	0.07		0.7
Swift Current, Sask.	2,392	27.47	30.11	+.04	21.7	+13.7	31.5	11.9	52	−12	0.17	−0.57	1.7
Medicine Hat, Alb.	2,144	27.78	30.11	+.06	26.6	+15.4	36.1	17.1	51	−18	0.10	−0.57	1.0
Calgary, Alb.	3,428	26.48	30.19	+.20	27.2	+13.7	38.3	16.2	58	−16	0.84	+0.21	4.9
Banff, Alb.	4,521	25.46	30.22	+.24	22.5	+3.3	34.4	10.7	47	−24	0.36	−0.56	3.6
Prince Albert, Sask.	1,450	28.46	30.12	+.03	12.4	+15.4	24.4	0.4	43	−25	0.19	−0.50	1.9
Battleford, Sask.	1,592	28.30	30.12	+.03	16.6	+16.5	27.5	5.8	48	−20	0.14	−0.23	1.4
Edmonton, Alb.	2,150	27.72	30.08	+.06	21.9	+13.6	31.3	12.6	50	−18	0.20	−0.47	2.0
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.96	30.22	+.22	42.7	+3.2	47.0	38.4	53	34	0.45	−3.65	0.0
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	30.03	30.20	+.09	62.0	+0.5	69.0	55.1	74	47	5.66	+1.22	0.0

LATE REPORTS, JANUARY, 1928

Sydney, C. B. I.	48	29.77	29.82	−.11	22.9	+2.4	29.9	15.9	52	−5	5.55	+0.45	28.5
Halifax, N. S.	88	29.76	29.87	−.10	25.0	+3.2	34.5	15.5	52	−6	5.87	+0.10	12.7
Yarmouth, N. S.	65	29.73	29.80	−.20	28.5	+2.2	35.7	21.3	48	4	6.01	+0.35	41.3
Charlottetown, P. E. I.	38	29.72	29.76	−.20	19.0	+2.0	27.5	10.5	50	−8	4.12	+0.16	26.5
Chatham, N. B.	28	29.70	29.74	−.23	9.0	−0.8	20.9	−3.0	48	−19	3.10	−0.49	20.6
Doucet, Que.	1,236				−3.8		10.0	−17.5	34	−50	3.10		31.0
Medicine Hat, Alb.	2,144	27.74	30.09	+.02	19.9	+14.4	28.9	10.9	50	−36	0.70	+0.13	7.0
Calgary, Alb.	3,428	26.40	30.11	+.08	22.8	+14.4	38.4	12.2	59	−30	0.49	−0.04	4.9
Banff, Alb.	4,521	25.40	30.19	+.19	19.5	+7.4	27.5	11.5	51	−31	0.73	−0.46	6.8
Edmonton, Alb.	2,150	27.64	30.01	−.02	16.1	+14.3	25.2	6.9	43	−40	0.35	−0.33	1.2
Kamloops, B. C.	1,262	28.94	30.28	+.32	24.2	+1.2	29.7	19.8	43	−14	1.23	+0.41	12.3
Victoria, B. C.	230												
Barkerville, B. C.	4,180	25.64	30.07	+.18	19.9	+2.1	26.0	13.8	42	−24	2.70	+0.10	20.5
Estevan Point, B. C.	20				43.5		47.4	39.7	54	25	18.54		0.8
Prince Rupert, B. C.	170				37.8		43.4	32.2	51	16	7.61		3.0

Chart I.—Departure (°F.) of the Mean

Chart I. Departure (°F.) of the Mean Temperature from the Normal, February, 1928

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

Chart II. Tracks of Centers of Anticyclones, February, 1928. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by Wilfred P. Day)

February, 1928. M. W. R.

Chart III. Tracks of Centers of Cyclones, February, 1928. (Inset) Change in Mean Pressure from Preceding Month

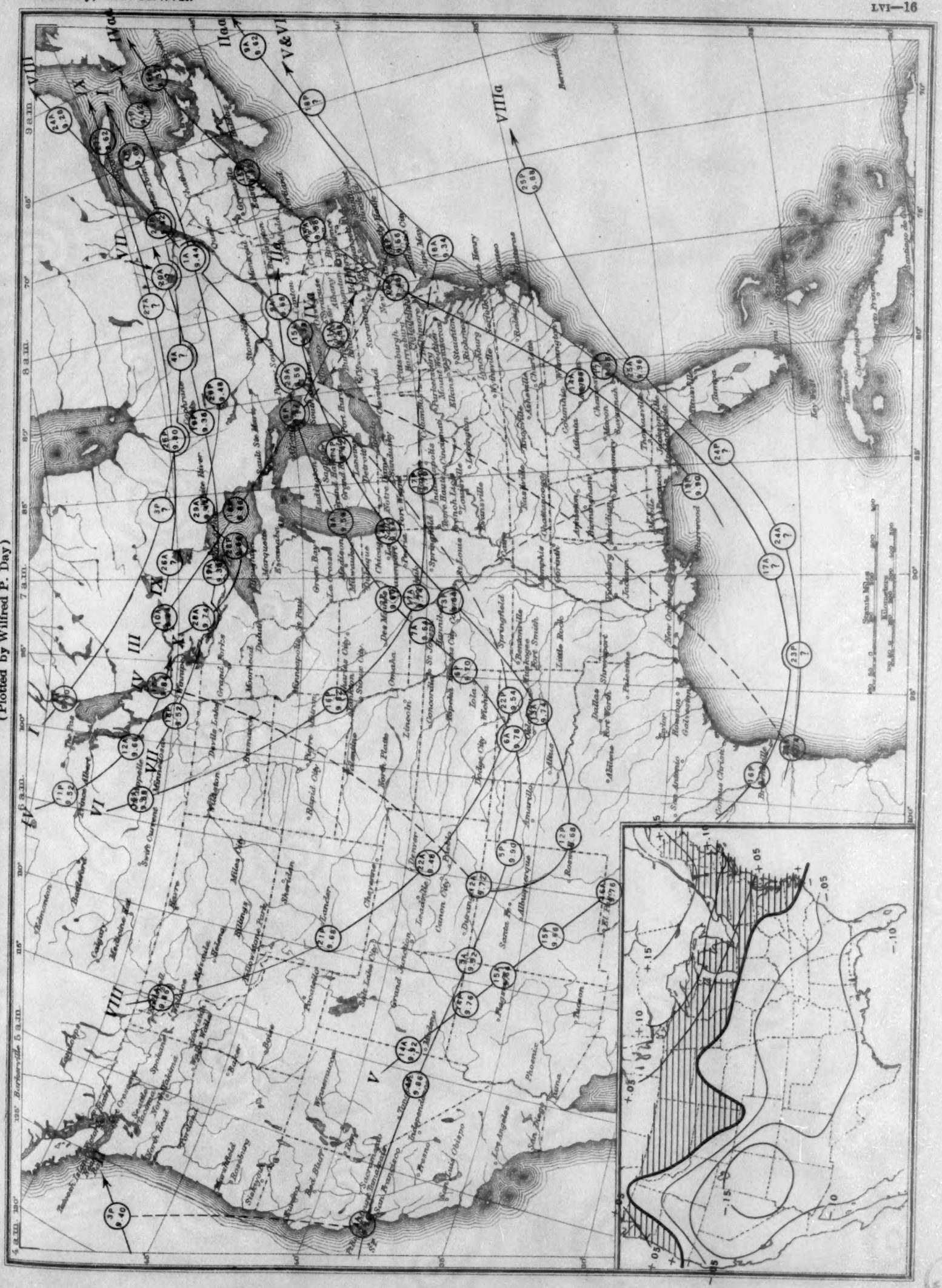
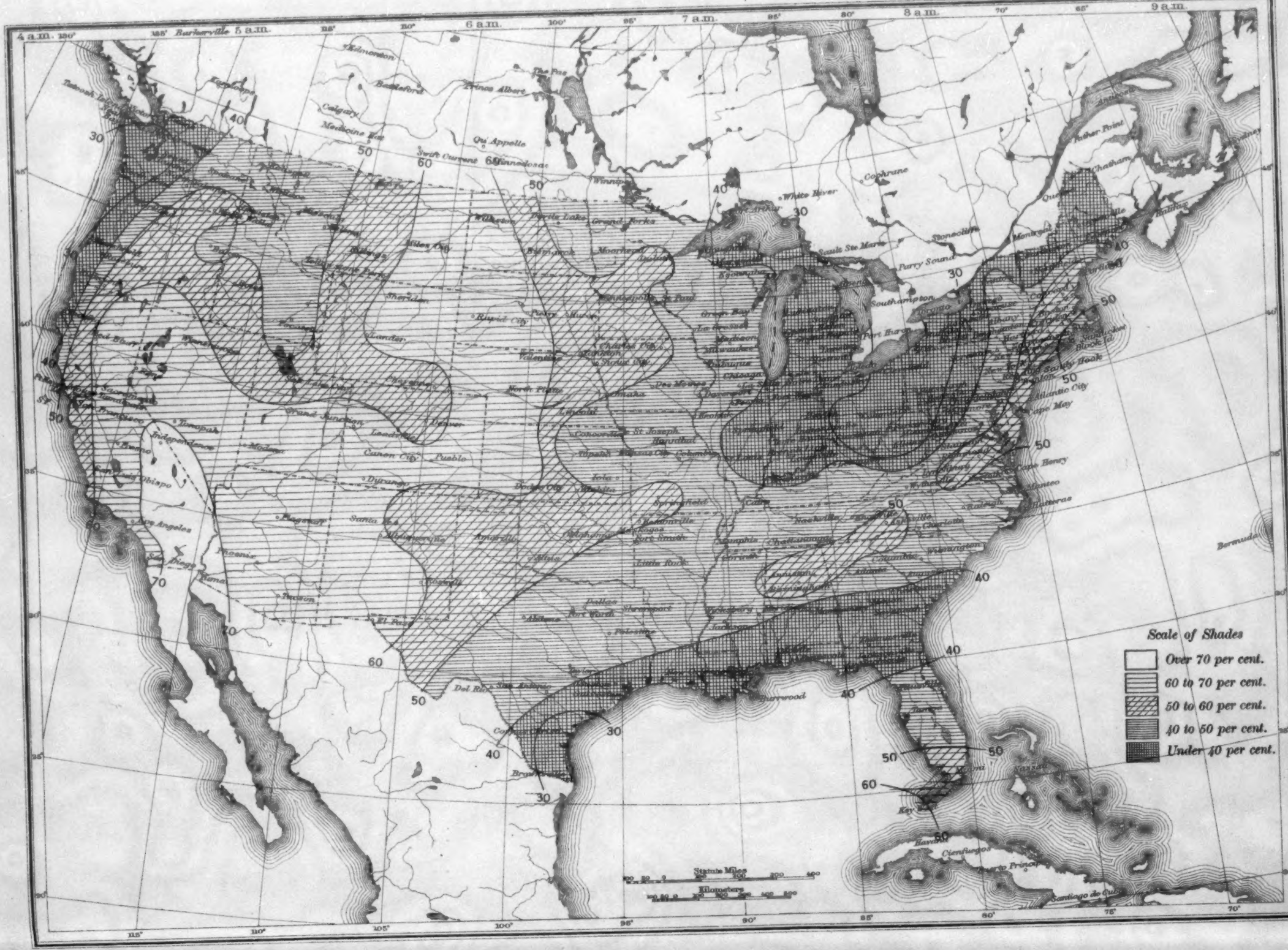


Chart III. Tracks of Centers of Cyclones, February, 1928. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Wilfred P. Day)

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, February, 1928



February, 1928. M. W. R.

Chart V. Total Precipitation, Inches, February, 1928. (Inset) Departure of Precipitation from Normal

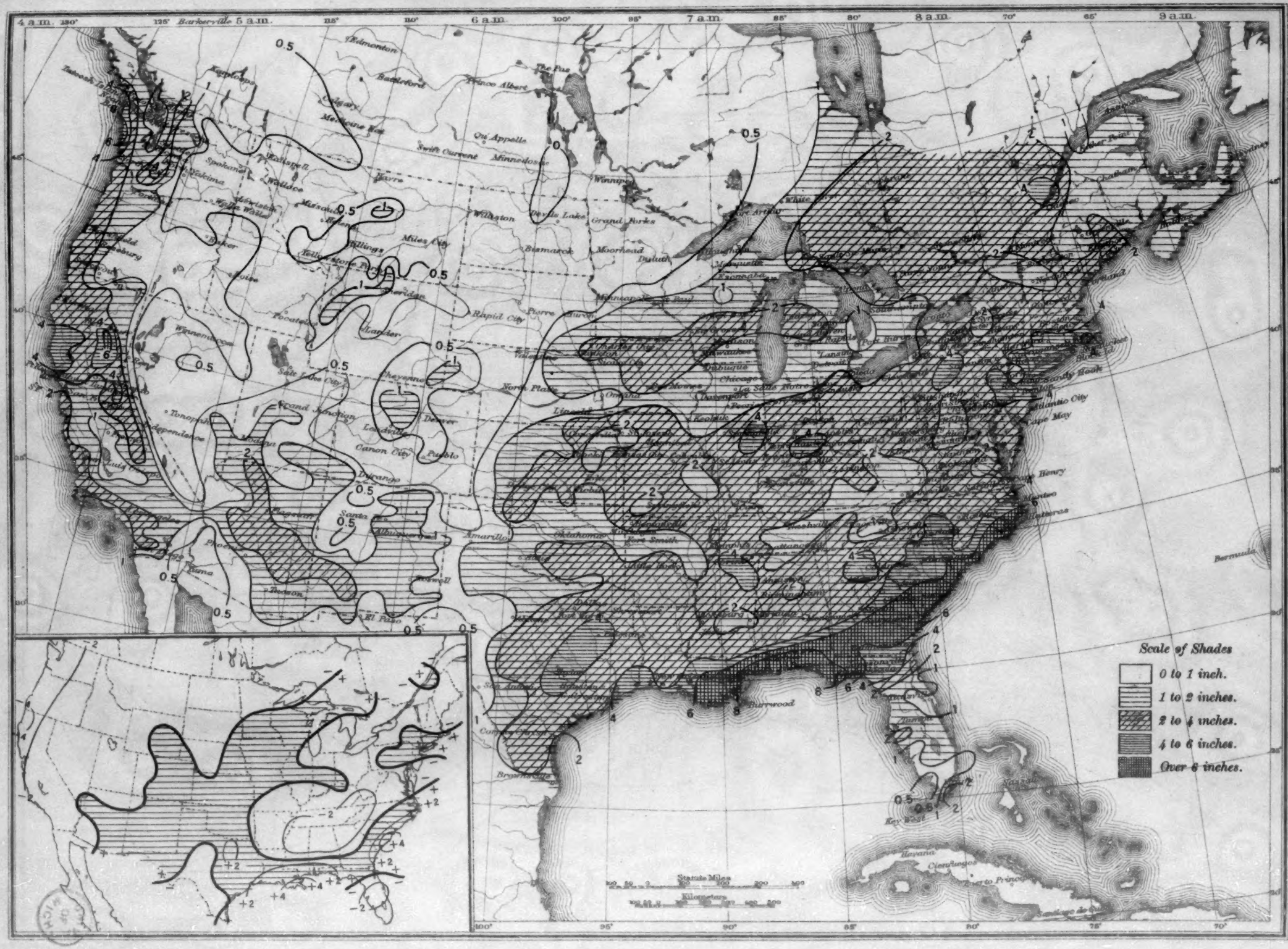
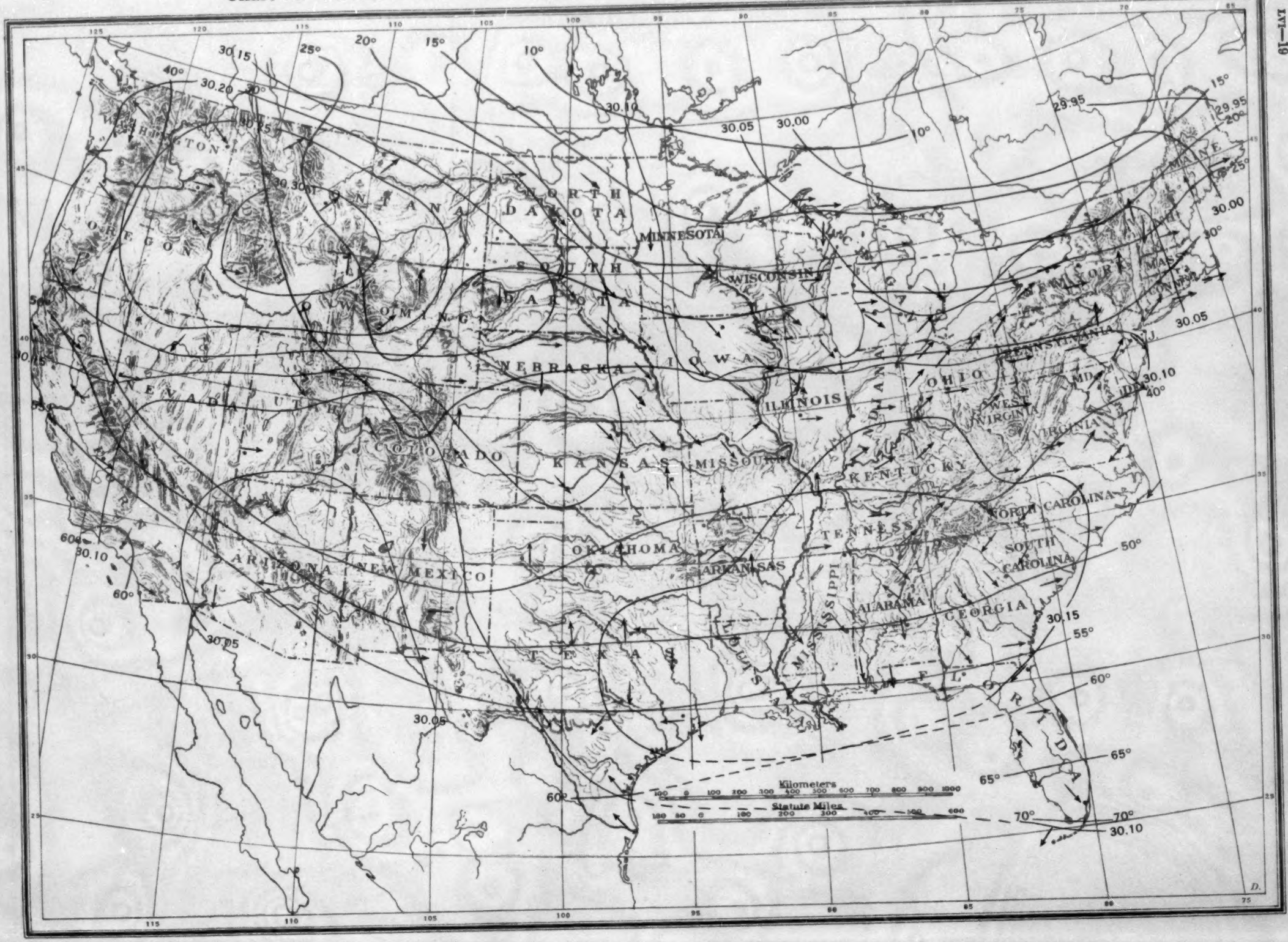


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, February, 1928



February, 1928. M. W. R.

Chart VII. Total Snowfall, Inches, February, 1928. (Inset) Depth of Snow on Ground at end of Month

Chart VII. Total Snowfall, Inches, February, 1928. (Inset) Depth of Snow on Ground at end of Month

Chart VIII. Weather Map of North Atlantic Ocean, February 17, 1928

Chart VIII. Weather Map of North Atlantic Ocean, February 17, 1928

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, • rain, ▲ hail or sleet, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

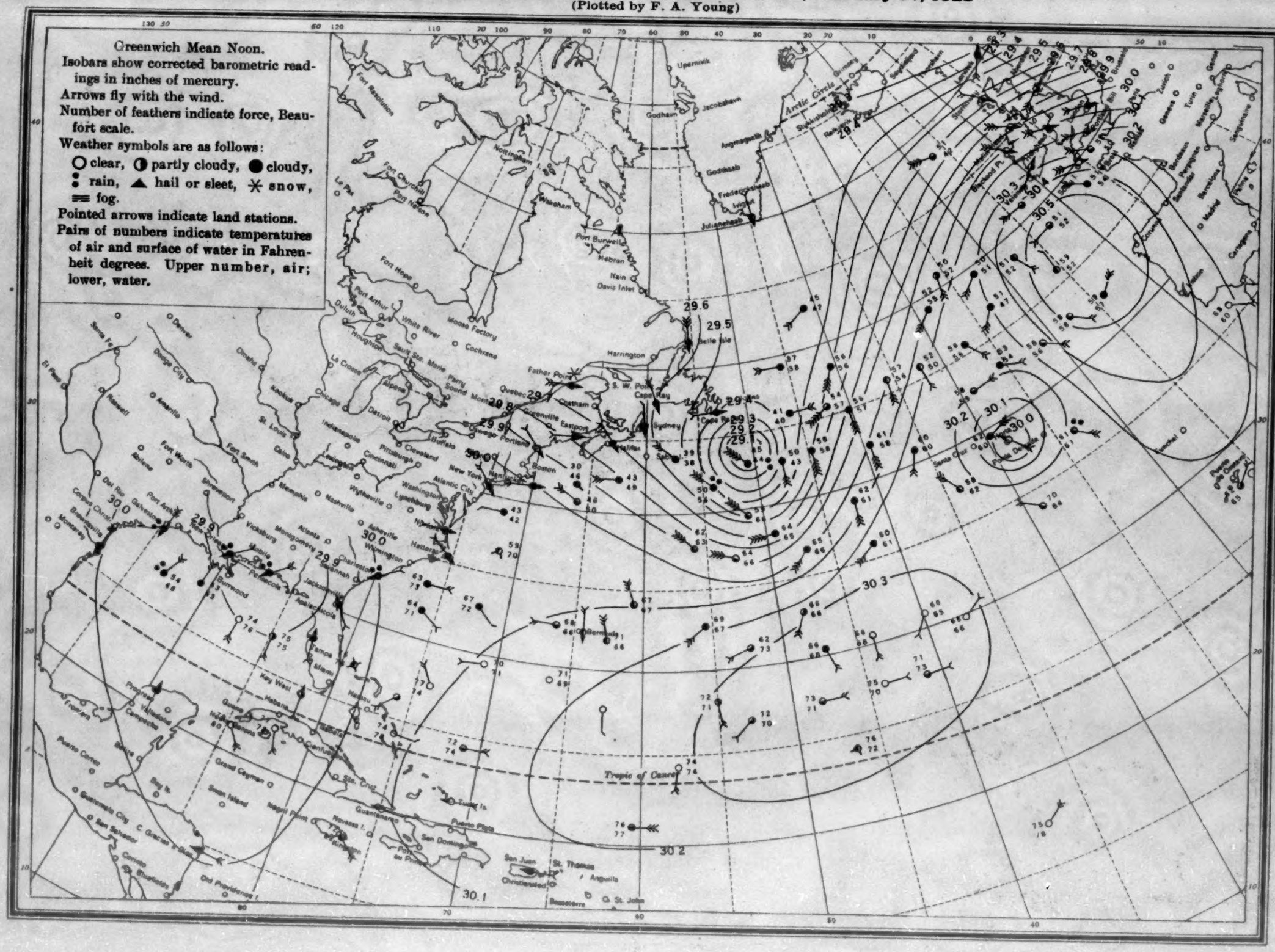


Chart IX. Weather Map of North Atlantic Ocean, February 18, 1928

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Chart X. Weather Map of North Atlantic Ocean, February 19, 1928

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

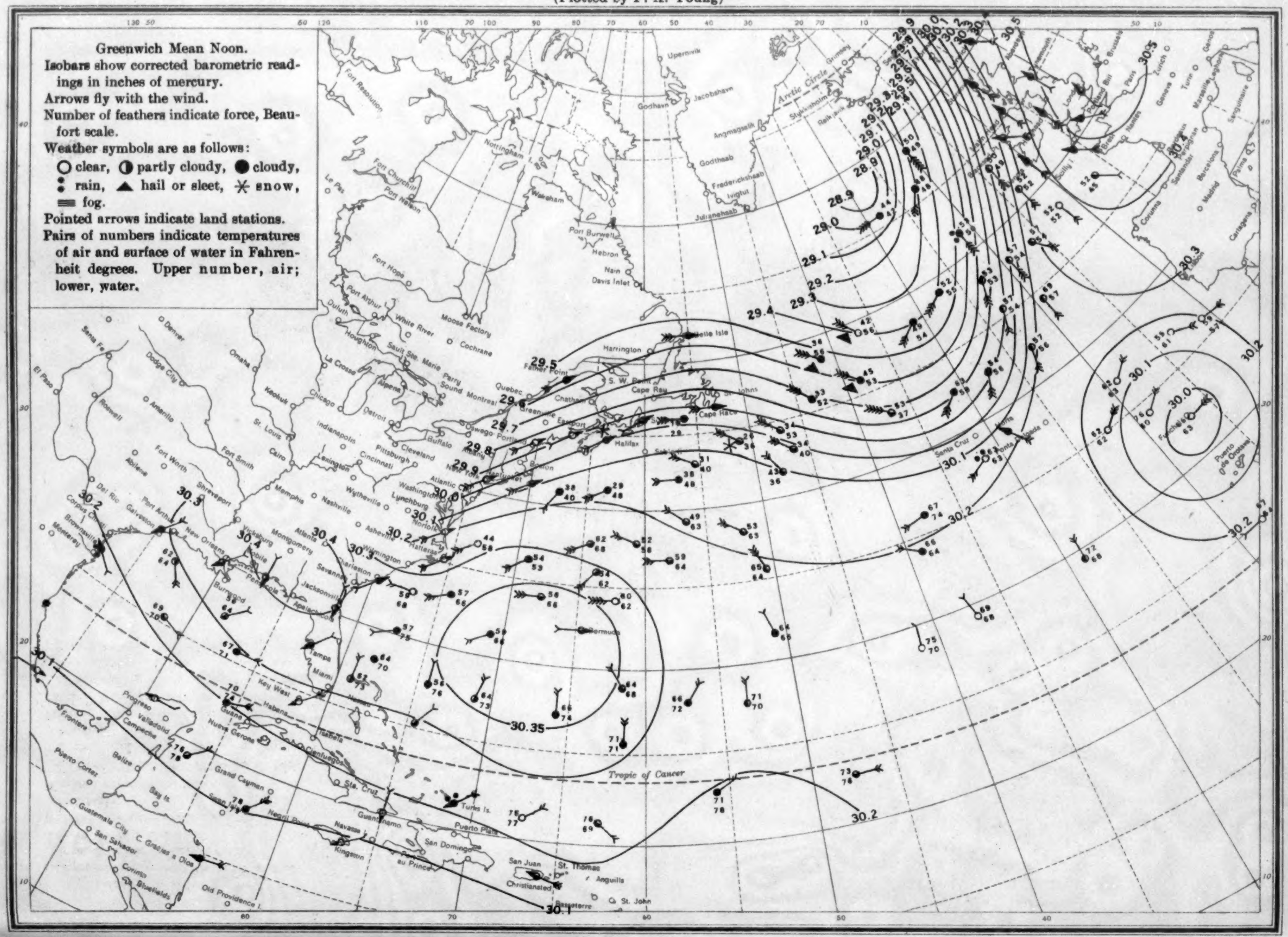
Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Chart XI. Weather Map of North Atlantic Ocean, February 20, 1928

(Plotted by F. A. Young)